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UNIVERSITY-PRODUCTIVE SECTOR LINKAGES

REVIEW OF THE STATE-OF-THE-ART IN AFRICA

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University-Productive Sector Linkages:

Review of the State-of-the-Art in Africa

prepared by M.N.B. Ayiku

for the Association of African Universities

ACCRA
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INTRODUCTION

In July 1972, the Association of African Universities (AAU) organized a seminar in Accra on the topic of "the Edification of the African University: problems of the 1970's". This seminar was designed to give academics an opportunity to achieve a critical overview of the contemporary state of the universities and draw the broad outlines of desirable development in the future. In his introduction to the proceedings, the Rector of the University of Lagos, Professor J.F.A. Ajayi, commented:

> "The task of winning acceptance for the idea of the university in Africa is still unfinished, not only in seeking to adapt and identify it, but also in creating vigorous academic communities that are prepared to take the initiative in seeing that the universities serve the best interests of the nation[1]."

Twenty years later, the problems related to the relevance of the African university's contribution to the development of the continent or the need to affirm its identity and defend its legitimacy no longer arise in the context of debates over principles, but in terms of concrete, urgent actions.

No one today would deny that the African university must affirm its own identity outside the traditional concept of a "fortress dedicated to the pursuit of knowledge, the development of the student and the demand for absolute freedom in research and teaching". African universities need to concentrate on solutions to urgent problems (such as productivity, jobs, health care, education, etc.), with the ultimate aims of bringing about social change, economic modernization and the training and development of human and natural resources.

To achieve this goal, the university must focus on a dual task of liberation:

- liberation from intellectual subjugation to the outside world, as reflected in the forms, institutions and rites of an outworn colonial mimicry(?),

- liberation from paternalistic condescension towards the African masses who are considered intellectually inferior.

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[1] *The Edification of the African University*, ed. T.M. Yesufu, AAU, 1975.

This dual liberation will be achieved only when the university's pre-eminent, irreversible commitment is to mastering local conditions through the development of solid, empirical bases that can be used to postulate an original world view centred on African societies, and to articulate more effectively its research and teaching mission.

The institution's legitimacy in the eyes of the African working masses is at stake here. The aim is to enlist all the university's intellectual capabilities in the service of the African nation, since its resources, albeit allocated by the State, are generated by African producers.

Everyone who has the development of the continent at heart is agreed on these principles.

Unfortunately, the concrete actions designed to put these principles into practice have remained notable for their scarcity. An optimistic, positive response is therefore in order to this new AAU initiative, the objective of which is to bring the university closer to the local productive sector.

Many researchers and academics have deplored the fact that African states have chosen outward-directed industrialization policies, with their heavy dependence on imported technology and expertise and concomitant tendency to marginalize the local production of research technology. There are nevertheless communities of producers, often operating as "informal" or micro-businesses, whose R&D needs could be met by university research. It is up to the university to establish linkages with such producers aimed at upgrading their tools, their management capabilities, product quality, the efficiency of manufacturing processes and financing and distribution methods. The ultimate aim here is to develop technological capability--rather than to create "appropriate" gadgets--by selectively focussing on the needs of and demand for an industry based on local engineering and equipment in order to bring about technological change and innovation. Linkages such as this enable the university to embark on the path of liberation, identity and legitimacy.

IDRC, in partnership with the AAU and the African universities, will contribute intellectually and financially to this regional effort, which fits in perfectly with its mandate and its regional strategy.

Dakar, January 18, 1991

Pierre T. Sané

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PREFACE

This review of the literature on the state-of-the-art of University Productive Sector Linkages in Africa has been prepared for the Association of African Universities with generous funding from the IDRC Regional Office in Dakar. It is a product of research carried out by a consultant who undertook missions to the headquarters of: UNESCO, UNIDO, UNCTAD, ILO, ECA and ARCT; and to regional offices of IDRC in Dakar, and UNESCO/ROSTA in Nairobi as well as to the universities in Addis Ababa and Nairobi and the Helsinki University of Technology. The consultant also visited the Ministry of Science and Technology and other research institutes in Nigeria. The assistance offered by all organisations and institutions visited is hereby acknowledged and appreciated.

The report surveys the situation in the continent and also outlines some of the experiences in the industrialised as well as the newly industrialising countries without attempting to suggest the lessons which can be learnt from them. The AAU intends to pursue this subject further with a number of activities which will focus on evolving strategies to develop and strengthen linkages between the universities and small and medium scale enterprises in the productive sector.

The support from IDRC through its regional office in Dakar, Senegal is greatly appreciated.

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LIST OF ACRONYMS

AAU	Association of African Universities
ADB	African Development Bank
APO	Asian Productivity Organisation
APPERD	Africa's Priority Programme for Economic Recovery Development
ARCT	African Regional Centre for Technology
CASTAFRICA	Conference of Science and Technology Ministers in Africa
CICD	Centre for International Development and Cooperation
CIDA	Canadian International Development Agency
DANIDA (Denmark)	Danish International Development Agency
ECA	Economic Commission for Africa
EEC	European Economic Community
ERC	Engineering Research Centre
ESF	Engineering Society of Finland
ESEE	European Society for Engineering Education
FIIRO	Federal Institute of Industrial Research, Oshodi
FAO	Food and Agricultural Organisation
GDP	Gross Domestic Product
HRD	Human Resources Development
HUT	Helsinki University of Technology
IACEE	International Association for Continuing Education in Engineering
IDDA	Industrial Development Decade for Africa
IDRC	International Development Research Centre
IIT	India Institute of Technology
ILO	International Labour Organisation
IRPA	Intensification of Research Priority Areas
KIST	Korean Institute of Science and Technology
LDC	Least Developed Country
NASSI	Nigerian Assosiation of Small-Scale Industrialists
NGO	Non-Governmental Organisation
NIC	Newly Industrialising Country
NISER	Nigerial Institute of Social and Ecnomic Research
NSF	National Science Foundation (USA)
OAU	Organisation of Africa Unity
POSCO	Pohang Iron and Steel Company
POSTECH	Pohang Institute of Science and Technology

PRODEC	Programme for Development Cooperation, Helsinki School of Economics
RIST	Research Institute of Science & Technology
R&D	Research and Development
SAREC	Swedish Agency for Research Corporation with Developing Countries
SCC	Science Council of Canada
SCS	Science Council of Singapore
SISIR	Singapore Institute of Standards and Industrial Research
SMI	Small and Medium-scale Industries
SRI	Stanford Research Institute
SSI	Small-Scale Industry
STDB	Thai's Science and Technology Board
S&T	Science and Technology
TTC	Technology Transfer Centre, Ghana
UNCTAD	United Nations Conference on Trade and Development
UNCTC	United Nations Centre for Transnational Corporations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Culture Organisations
UNIDO	United Nations Industrial Development Organisation
UNPAAERD	United Nations Programme of Action for African Recovery and Development
UPLBFI	The University of Philippines Los Banos Foundation Inc.
UPS	University Productive Sector
USA	United States of America
USAID	United States Agency for International Development
WB	World Bank
WHO	World Health Organisation
WIPO	World Intellectual Property Organisation

EXECUTIVE SUMMARY

1. THE PROBLEM

The economies of virtually all African countries are plagued with serious problems. These problems include low productivity and high foreign debts resulting in the establishment of austerity measures. But the most serious problem is the low level of industrial development in almost all the African countries.

One solution to the problem is to extend the role of African universities beyond the traditional role of teaching and research. Specifically, there is the need to link some activities of the universities to the productive sector. But in view of the unfavourable environment, within which industry operates in Africa, and other constraints the real problem is whether the universities in Africa can develop effective linkages with SMIs.

2. TERMS OF REFERENCE

The terms of reference of this study are to:

(i) review the current status of university linkages with the SMI sector,
(ii) study the research and service needs of the SMI sector in Africa and other Third World countries,
(iii) prepare and submit a report on a review of the state-of-the-art; and
(iv) make recommendations to the AAU.

3. THE PECULIAR NATURE OF THE PROBLEM IN AFRICA

This report emphasises the fact that many African countries lack adequate S&T policies, provide inadequate support for R&D, lack or possess a poor science culture and have societies dominated by short-sighted policies of both politicians and bureaucrats. It is the combination of all the above which renders the problem complex but singularly peculiar to the African continent.

4. THE CONCEPTUAL FRAMEWORK

The economies of the majority of African countries since the 1980s have been facing crises as a result of a multiplicity of problems. The per capita GDP, share of manufacturing in total GDP, and adult literacy fell. Thereby the proportion of the number of countries in Africa in the Least Developed Country (LDC) category rose to a staggering two-thirds of the world total. Thus over half of the member states of the Organisation of African Unity (OAU) now belong to the LDC category.

The impact of structural adjustment programmes with their characteristic harsh conditionalities have proved harmful to the rural poor. But the SMI sector still consists of a large number of poorly organised or unorganised proprietorships with little or no say in the decision making process. This reduces the contribution of SMIs (a large number of which are owned by Africans) to national development. These industries merit considerable encouragement, for they have the potential to provide rural employment, entrepreneurial opportunities for women; contribute to the improvement of income distribution and, more importantly, they utilise local raw materials, including agricultural raw materials.

5. THE RESEARCH AND SERVICE NEEDS OF SMIs IN AFRICA.

The research and service needs of SMIs in Africa are many. This is because the SMI sector has, for a long time, been neglected. The research and service needs of SMIs reviewed in this report are summarised below:

5.1 Research Needs

- Raw Material Identification and Testing
- Product Development, Testing, Quality Control and standardization
- Research into appropriate Technologies
- Assessment of Needs & Opportunities
- Information Needs
- Contract Research

5.2 Service Needs

Human Resource Development
- special and short term courses
- traditional courses
- continuing education
- entrepreneurial training
- management

Consulting
- feasibility report preparation
- accounting
- marketing

Socio-economic support
- Evaluation and Assessment
- Study of impact of technologies
- techno-economic studies

Technology Contracts
- Negotiations
- Contract drafting

5.3 Finance
- dissemination of sources & types of finance
- special programmes

5.4 Other Service Needs
- Dissemination of Research Results
- Extension Services
- Promotional Needs

6. STATE-OF-THE-ART REVIEW OF UPS LINKAGES

There are no set standards of strategies. The strategies depend largely on the circumstances; the level of technological development, the needs of industry, and the involvement of the government,among others. There are, therefore, a multiplicity of forms of UPS linkages. The forms of UPS linkages reviewed in this report are summarised below:

6.1 R & D Linkages

- Individual & informal R & D
- Research Centres, Foundations, etc
- Public or Private Sector Linkages firms
- Rural or Appropriate Technology
- Technology Parks and Incubators
- Research Consortia
- Committee System and Ministerial units

6.2 Human Resource Development

- The Teaching Company
- Continuing Education Centre
- Cooperative Education
- Industrial Training and Exchange

6.3 Consultancy

- Individual Consultancy
- Consultancy Centre or Institute or Foundations
- Spin-off Companies Patent Licensing
- University Liaison Office

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Problems and Benefits of Interaction

There are several problems which plague UPS linkages. These problems arise because of the multi-disciplinary nature of UPS activities, the attitude of the universities, the lack of autonomy of UPS centres and the inability of the African industrialists to clearly define their problems, finance their own researches and perform their own in-house research, among others.

But there are several benefits accruing from the interactions between universities and industry. Among these are that: it bridges the gap between university and industry; enhances the reputation of the university, the staff and the students; assists in making the curricula of university courses more relevant to the needs of society generally; benefits the industrial firms and the industrial

sector generally and, in the course of time, as industries develop, will benefit the universities financially.

7.2. The Case for State Intervention

The role of the State in the establishment of UPS linkages is widely accepted even in the advanced capitalist countries. The state has the responsibility to institute an explicit industrial policy, R&D policy and establish educational systems which will respond quickly to changing needs. The pervasive attitude of inertia and excessive bureaucracy and the propensity to import technology can only be addressed by the state. There is also the need for direct support for student research in priority areas, creation of a strong engineering sector to support commercialisation of R&D results and the provision of resources to effect linkages. The main source of funding for forging university-industry linkages in Africa, should be African Governments.

8. SUMMARY OF RECOMMENDATIONS

The AAU should seek technical assistance from NIC experts to undertake analysis of some country characteristics and needs so as to determine the country specific linkages. This task must be performed with the full cooperation of heads of selected universities in Africa.

8.1 Awareness Creation and Promotional Activities.

The AAU should organise an all African regional conference to discuss relevant issues such as the establishment of and funding sources for UPS centres; the relevance of programmes such as UNIDO's IDDA II, Trade Fairs, workshops, exhibitions, study tours and an information Bank of UPS linkage activities in Africa; and the regular monitoring of these activities with a view to promoting the interests of the UPS centres.

8.2 The Role of the States in Africa

They must establish:

(i) explicit economic policies for the development of the SMI sector
(ii) explicit R&D policies (especially with respect to funding of R&D)
(iii) commercialisation and macro-eccnomic policies which promote UPS linkages.

8.3 Role of International Agencies

Some of the International Organisations such as IDRC, are heavily involved in creating the necessary awareness of the need to commercialise R&D results and also establish research productive sector linkages. They, however, need to go a step further by establishing university-industry units along the lines of the university-industry unit established by UNESCO. The AAU should use its good offices to begin a world-wide effort to persuade other key organisations such as ILO, UNIDO, UNCTAD, WHO, FAO, etc. to create university-industry units or at least, desks within their organisations to facilitate UPS activities in Africa.

8.4 Research

The AAU needs to sponsor or undertake research in the following areas:

(i) Criteria and standards for measuring achievement
(ii) Assessment of the impact of the technology developed and diffused
(iii) Study of the UPS Linkage organisation forms and management
(iv) Evaluation of locally developed technology prior to commercialisation
(v) Sources of funding

8.5 Funding Sources

Among other sources of funding UPS activities in African countries are the UNDP, IDRC, SAREC, the African Development Bank (Abidjan), etc.

PART I: BACKGROUND INFORMATION

1.1 INTRODUCTION

In spite of several declarations and programmes, such as the Industrial Development Decade for Africa programme (IDDA) established by the United Nations General Assembly a decade ago, and various resolutions passed by the Organisation of African Unity (OAU) the economies of virtually all African countries are plagued with serious problems. These problems have manifested themselves in low productivity and high foreign debts resulting in the establishment of austerity measures (ECA,1989a). However, the most serious problem is the low level of technological development, hence poor value added to many products produced by the African countries. African countries continue to be exporters of a narrow range of primary products of strategic importance to the advanced countries and importers of technology of all sorts. The technological problem of Africa has further been exacerbated by the rapid advances being made by the highly industrialised countries in the development of modern technology in areas such as information technology, biotechnology, genetic engineering, robotics and material science. These new technologies are being integrated into the old technologies or used to modernise offices, factories, agricultural production, etc.

The implications of the above issues are the subject of study, analysis and speculation by writers, including industrialists and academicians. It is clear, however, that technology is now heavily science based and, therefore, knowledge-intensive. Indeed, some of the new technologies are also capital intensive. Inspite of this development, many African countries are responding to these changes by adopting laissez-faire attitudes to the development of national scientific and technological capacity. Granted that there may be no explicit Science and Technology (S&T) policies backed by adequate financing of programmes to develop indigenous S & T capacity and specifically ensure that the research results benefit industry, there are, fortunately, regional institutions in Africa which are active, and are attempting to provide some leadership and direction to create the awareness of the need to develop indigenous technological capacity and link this to industrial production. One

such institution is the new and fledgling ASSOCIATION OF AFRICAN UNIVERSITIES (AAU).

It may appear obvious from the above that given the present poor state of industries in Africa and considering the rapid changes in world output of technology the role of the African Universities is simple: they should modernise their traditional teaching and research roles. Specifically, the teaching and research must serve a societal purpose - Development (AAU, 1989a). This role has in fact been advocated by the UN Economic Commission for Africa and accepted by many African writers including university professors (ECA, 1982). Since industry is the direct agent of development, it is argued, the problem in Africa reduces to that of effectively linking some activities of universities to the productive sector. This, it will be shown elsewhere in this report is not the real problem.

1.2 OBJECTIVES AND TERMS OF REFERENCE

Before stating the terms of reference of this study, it is necessary to state its immediate objectives, as seen by the AAU. The objectives are two-fold. The study aims, firstly, to outline the broad areas in which there is urgent need to enhance the role of universities in Africa in the development process of the continent; Secondly, to enunciate the necessary new policies and steps that the universities need to initiate to enhance the institution of successful university linkages with the Small and Medium-scale industry (SMI) sector.

Specifically, the terms of reference of this study are to:

(i) review the current status of university linkages with the SMI sector in Africa as well as in other regions of the Third World.

(ii) study the research and service needs of the SMI sector in Africa,

(iii) prepare and submit a report on a review of the state-of-the-art; and

(iv) make recommendations to the AAU.

The above terms of reference may be interpreted broadly to reflect the desire of the African countries to benefit from the technological experiences of the highly and Newly Industrialised Countries (NICs), so that universities in Africa in essence can design more adaptive and effective linkages appropriate to local conditions. Also, the terms of reference are, where appropriate, interpreted to include the role of the governments of the countries where the universities are located. For, unlike many of the advanced countries where there are established private universities which are recognised as pace setters, most universities in Africa are owned by the African governments. African governments must, therefore, have a large role to play.

This report is organised in four parts. The first part provides background information. In particular, the conceptual framework for the entire study is presented in this part. The second part reviews the research and service needs of the SMIs in Africa. In Part III, a review of the state-of-the-art of university-productive sector (UPS) linkages is presented with emphasis on the type of linkages likely to be most relevant to the African situation. The problems of establishing UPS linkages are also discussed in this part of the report. Part IV presents the conclusions and recommendations of the study. The appendices annexed to this report consist of a list of case studies, a list of references and the itinerary of travels undertaken to collect material for the study.

1.3 METHODOLOGY

The methodology followed in this study is a combination of desk research, visits to various institutions in Senegal (Dakar), Europe (Paris, Helsinki, Vienna and Geneva), Ethiopia (Addis Ababa), Nigeria (Lagos) and Kenya (Nairobi), and informal discussions with various officials of the organisations visited. The discussions with officials conducted during the visits were mainly informal. They were not directed at discussing substantial issues but at determining the amount of studies already conducted by various organisations and individuals on the subject.

Before embarking on visits to institutions holding documents on the subject matter under study, the various relevant documents readily available locally were studied. These materials fall into the areas of technology transfer, university research, problems of introducing innovations into the production system, problems of the industrial sector in Africa, research funding, etc,. The preliminary desk research was followed by an in-depth study of over one hundred (100) documents retrieved from various African and overseas institutions, as annexed to this report.

The AAU made the necessary arrangements for the visits to the relevant organisation in Europe and Africa. During the visits considerable material was collected. Not all the materials collected are listed in the appendix (see Appendix B) annexed to this report for the simple reason that some of them are only tangential to the real issues of interest in this report.

No attempt is made in this report to extensively enumerate bibliographic sources nor quote extensively from these sources, though some of the source materials are quoted in the text. The reason is two-fold; first, the approach adopted here is analytic, and attempt is made to extract the salient principles from the cases on established university productive sector linkages; secondly extensive citations are avoided in order not to unnecessarily over-burden the report and in the process obscure the main points being made. In this connection, it may be remarked here that there are a multiplicity of forms of organisations designed to effect UPS linkages.

A conscious effort is made to avoid making dogmatic statements which do not apply to a majority of African countries. The statements made herein are, therefore, those supportable by the evidence in the literature.

1.4 THE PECULIAR NATURE OF THE PROBLEM IN AFRICA

Various linkages are designed to solve specific linkage problems. They are largely country specific and provide a rare insight into the main concerns of those countries. In addition, the nature of the problems which these linkages are designed to address, although not unique, nevertheless provide a further insight into the

level of technological development in those countries. This country specificity of linkages and level of technological development call for a brief outline of the peculiar nature of the problem of linkages in Africa. The African problem is peculiar in that many African countries lack adequate S&T policies, provide inadequate support for R&D, possess a poor science culture and have societies dominated by short-sighted policies of both politicians and bureaucrats.

1.4.1 Lack of S&T Policies

The lack of adequate S&T policies is evidenced by the fact that prior to CASTAFRICA I (1974) only five countries in Africa had established a framework for S&T policies at a high political level. But twenty African countries established an institutional framework for S&T policies between CASTAFRICA I and CASTAFRICA II held in Arusha, Tanzania in 1988 (UNESCO, Doc. 69, 1988b). Even in countries where S&T institutions have been established there does not appear to be a clearly defined institutional framework for effecting university productive sector (UPS) linkages. Few of the universities in Africa have taken the initiative to actively establish linkages with the productive sector. And even in those few African countries where these linkages exist they are weak, poorly financed and largely ineffective.

1.4.2 Inadequate Support for R&D

The poor level of funding for UPS linkages in Africa is due to a number of factors largely outside the control of the universities. Firstly, African governments do not place a high premium on R&D in that very few of the governments spend more than 0.5% of their Gross Domestic Product (GDP) on R&D inspite of the many resolutions passed in international fora urging developing countries to devote at least 1.0 % of their GDP to R&D. Egypt is one of the few countries in Africa with an extensive R&D system headed by a Minister of Research. Egypt's expenditure on R&D was 1.2% of GDP in 1987 (UNESCO, 1988b).

Secondly, S&T is invariably relegated to the background during periods of economic crises: African governments have had and are still having to face economic crises.

Thirdly, international lending institutions such as the World Bank do not seriously link the development of indigenous technological capacity to the package of reforms they advocate for Africa.

1.4.3 Unstable Economic Policies

It is largely the mismanagement of the economies of African countries which usually cause multilateral lending institutions to impose drastic solutions resulting in frequent changes in economic policies in the African countries. These unstable economic policies have rendered theories of "demand pull" and "supply push" for technology development largely irrelevant in the African situation since the pursuit of short term gains by business executives - both indigenous and foreign - tend to supersede any other consideration, especially that of medium and long-term planning.

1.4.4 Poor Science Culture

In countries where the local culture is heavily scientific, changes in economic policies rather urge the people to be technologically innovative and thereby take advantage of the situation for profit. In Africa, however, the scientific culture is so low that many people do not seem to appreciate the implications of the age-old adage that 'necessity is the mother of invention.' Thus in Africa, one is more likely to find the elite parading the corridors of political power for a special import licence to import, for example, an apparently minor part of a car instead of teaming up with experienced local mechanics to design and fabricate that part from local scrap materials. This situation still persists because science teaching is still poor in the primary schools in Africa. There are few good science museums, exhibitions and competitions to challenge and stimulate the imagination of the youth, and thereby diffuse the culture of science in African societies. Universities are rarely approached by the governments, who own them, with scientific or technological problems crying for solutions. This is

partly due to the fact that technocrats are not adequately equipped by the very nature of their training to recognise that those problems are scientific and technologically-based and need to be solved locally; and partly because of their own vested interests.

The creation of a climate conducive to the growth of science and technology should be a major aim of all African countries (UNESCO, 1987). But there is the need for concrete action. Korea tremendously improved its climate for S&T by launching a nation-wide Science Movement (popularly called KWAKUAKHWA UNDONG), designed to apply scientific principles to all levels of national life. This was done by the government with the cooperation of the academic and industrial communities and the mass media (UNESCO, 1985). Again, the Singapore Science Council (SCS) is currently involved in arousing the curiosity of visitors, especially those without a science background through hands-on exhibits, graphics, live specimens, microcomputers and selected video shows. Besides the exhibition galleries, there are also temporary exhibitions set up from time to time with themes pertinent to either educational, economic, social or technological development in Singapore. There are also Omniplanetarium, Hall of Science and Technology Gallery (SCS,1988).

1.4.5 The Interests of Policy Makers in Short Term Solutions

Politicians or bureaucrats in Africa tend to be more interested in short-term solutions to problems facing Africa. For example, a policy maker does not find anything wrong in negotiating a contract or using government procurement power to import a hundred (100) handpumps instead of liaising with a local engineering department of a university to fabricate similar pumps developed locally using available local materials and thereby specifically linking research to industry. Thus unpatriotic and unethical motives and actions create negative barriers to the conscious efforts being made to give indigenous technology in Africa the desired pull for meaningful development.

In spite of these and other societal problems which admittedly influence the actions and attitudes of universities toward development, the underlying thesis of this report is that the universities in Africa have their specific role to play in designing

effective structures or mechanisms which should link them to the productive sector, to mutual advantage.

1.4.6 The Definition of SMIs is Unclear

There does not appear to be a fixed definition of SMIs for all Africa countries. This is desirable since the various African States are at various stages of development. For, a standard definition will render the same industry large-scale in one African state but small-scale in another state. But SMIs must be properly defined since programmes and policies intended for the benefit of SMIs must clearly identify them as the beneficiaries.

In African countries where attempts have been made to define SMIs the definitions appear to vary from one organisation to another within the same country. In Ghana, for example, the Industrial Statistics define small scale industries (SSIs) as those enterprises employing less than 30 persons. The rest are lumped together as either medium or large scale enterprises. But the 1987 Ghana Industrial Census defines SSIs as those enterprises employing less than 10 persons. Medium-scale industries are defined as those employing more that 9 persons but less than 30. The confusion persists inspite of the fact that the National Board for Small-Scale Industries is mandated by its nine-year old Act of establishment "to establish the criteria that constitute a small-scale industry" (Act 434, The National Board for Small-scale industries Act, 1981, section 4(a)). (It is interesting to note that UNIDO defines small-scale industries as those with less than 150 employees on their pay roll!)

The problem of defining SMIs is further complicated by the fact that there are different qualifiable variables in use. These include total value of assets, number of employees, sales volume (turn over) and volume of output. In addition to defining SMIs in terms of number of employees, the National Investment Bank (NIB), for example, defines SMIs in terms of value of fixed assets. This is currently fixed at not more than 10 million Ghana Cedis for small-scale industries and between 10 and 30 million Ghana Cedis for medium-scale industries (TTC, 1990). The implication of the definition emphasising the value of assets is that a capital intensive industry is necessarily not a small-scale industry.

The Central Bank of Nigeria and the Ministry of Science and Technology define small-scale industries as those industries with turn over of less than 500,000 Nigerian Naira. But the Nigerian Bank for Commerce and Industries, for its purposes, defines as small-scale enterprises with a turn over of not more than 750,000 Nigerian Naira (Landi,J.H. and A. Diallo, 1988). These definitions emphasise the fact that productivity in terms of value of turnover is the activity which should determine the classification of an industry and not, say, number of employees. For, a significant number of employees in a particular enterprise may be under-employed or idle.

The multiplicity of definitions emphasise the fact that several African countries have not been seriously considering SMIs in the formulation of their economic policies. But the differences in definitions may also suggest that there is the need to define SMIs to suit particular purposes such as allocation of credit, monetary guidelines and supply of inputs. In this report no attempt is made to define SMIs. It is, however, suggested that African countries should establish a fairly uniform criteria to guide the various institutions in defining small-scale industries, even for their various purposes. This will enable them define SMIs more clearly in their policy documents and thereby encourage both private and public institutions in one country to apply the same definition. In this connection, is suggested that the total value of turn over should be used as the basic qualifiable criterion in the definition of small-scale industries. For, turn over can be more easily measured, fixed and varied, even on a yearly basis, than value of fixed assets.

1.5 THE CONCEPTUAL FRAMEWORK

1.5.1 Basic Problems of the African Economy

The economies of the majority of African countries in the 1980s were characterised by: (ECA, 1989a; ECA & UNIDO, 1989).

(i) a sharp decline in the capacity to import capital goods and attract technology through direct foreign investment due to a considerable fall in export earnings, and unfavourable investment climate.

Consequently, foreign aid remained the main channel for acquiring technology and investment capital:

(ii) high ratio of debt service to exports earnings:

(iii) dysfunctional human resource development as evidenced by a high rate of graduate unemployment, the hiring of a large number of foreign experts and the acceptance by graduates of jobs unrelated to their training:

(iv) forced structural adjustment programmes with harsh austerity components which tend to exacerbate the already deplorable living conditions of the urban and rural poor:

(v) abandoned development projects, and resort to crisis management for survival:

(vi) reliance on export of a narrow range of commodities whose prices are regularly falling, and imports of goods with ever-increasing prices:

(vii) high imports of factors of production:

(viii) unstable economic policies which tend to further erode the entrepreneurial base of many African economies:

(ix) weak institutional capabilities:

As a result of the above problems, per capita GDP, share of manufacturing in total GDP, and adult literacy fell. Thereby the proportion of the number of countries in Africa in the Least Developed Country (LDC) category rose to a staggering two-thirds of the world total. Thus over half of the member states of the Organisation of African Unity (OAU) now belong to the LDC category. All these negative trends occurred despite the declared programmes such as the Industrial Development Decade for Africa (IDDA), Africa's Priority Programme for Economic Recovery and Development (APPERD),the UN Programme of Action for African Economic Recovery and Development (UNPAAERD), the Lagos Plan of Action (1980-2000) and the Final Lagos Act (1980).

The IDDA Programme designed, to mobilise additional resources for the industrialisation of the African region, failed to achieve its goal. The APPERD, UNPAAERD, and the Lagos Plan of Action were more specific in content than the IDDA programme,in that they emphasised the development of small-scale industries (SSI), agriculture and the informal rural and urban sector. But today the informal sector is neglected and sometimes harassed.

1.5.2 The SMI Sector

The impact of structural adjustment programmes with their characteristic harsh conditionalities have proved harmful to the rural poor because of the high prices they have to pay for imports and the low rewards they receive for their products. The Small Scale Industry (SSI) sector still consists of a large number of poorly organised or unorganised proprietorships with little or no involvement in the decision making process. Unlike medium and large scale industries which are mostly foreign-owned with good financial base, SSIs are indigenous industries with inferior capital base and therefore merit considerable encouragement. Notably these SSIs have poor, or no research and training components. This is a linkage problem of SSIs which frustrates transfer of technology and thereby prevents indigenous industries from growing. They are not even 'mom and pop' businesses but "one-man-shows" mainly maintained for survival purposes. Even if they are not encouraged to grow to become medium or large scale industries, SSIs should serve as active platforms mainly for industrial and economic development.

It is well known that SMIs, especially the SSIs, provide rural employment, entrepreneurial opportunities for women and contribute to the improvement of income distribution. They also utilise local raw materials, including agricultural raw materials (UNCTAD, 1987). Therefore SMIs could encourage farmers to increase production. Regrettably, however, African countries do not seem to appreciate the immense potential of SMIs as active platforms for development. In fact, many of the countries in Africa are not in a position to clearly determine the scope of SMI industrial activities, define and provide appropriate type of information for SMIs and actively motivate SMI entrepreneurs. It is true that the World Bank has initiated activities in many African countries to train SMI entrepreneurs but this is no substitute for local initiatives.

1.5.3 The Commitment of the Universities is not Total

African universities have not responded quite effectively to providing solutions to some of the economic problems facing their countries. Often actions taken by the universities are motivated by the security interests of the individual staff members to survive. For example, some consultancies were established in many faculties in African universities to enable participants earn extra income in this period of austerity. Such fast buck expedient arrangements cannot become models for long term cooperation (Aminu,J., 1987).

The universities have not been able to adapt for the sole reason that they are still being molded and managed in the traditional way as teaching and research establishments. They jealously guard their right to determine what to teach, how to teach it and what type of research to conduct. The socio-economic milieu of Africa has changed but "the universities, however, have not adequately caught up. Some still stick to the old structure and offerings, with only a few modifications" (Awokoya,S.O.,1982). The structures of many African universities thus remain near rigid and fundamentally static. It is noted that Universities established in more industrialised countries such as Finland and France appear more adaptive and innovative in their structures. By contrast, "the universities of the less industrialised countries tend to be rigid, hierarchic, traditional and lacking autonomy with respect to their Ministries of Education" (OECD,1984). This lack of autonomy is largely created by the Ministries' desire to find ways and means of correcting what they perceive to be the defects in the university system which make it unresponsive to modern needs. But sometimes special interests, friction and stresses set off by internal factors in the universities also lead to external intervention and the erosion of university autonomy. This happened, for example, in Nigeria where university staff aspiring for high university offices, usually the vice-chancellorship, privately (and sometimes openly) solicit support from groups outside the university (Ibrahim, Y.A., 1987).

Even the few university departments which attempt to be innovative and forward-looking, do not receive the needed support from their governments. For example, they are poorly funded. The employees or staff receive little credit from their peers for the non-traditional functions which they perform. This is simply

because African universities still insist on publications, preferably in foreign journals, as the major criterion for personal advancement of the teaching staff.

African universities also interpret S&T mainly in terms of high level research and manpower training; hence the needs of SMIs such as entrepreneurship training, product and plant design, etc, are not adequately taken care of. But the lack of definitive policies on commercialisation and other related issues means that commercialisation is often left to foreigners to deal with, after the publication of the research results. This structural constraint works to the advantage of the advanced countries where high-technical facilities and expertise abound for the exploitation and commercialisation of research results as rapidly as possible.

Admittedly, many research results exist in many African university departments - but in the files. It is mainly the unearthing of these results and the formulation of strategies to facilitate their delivery to the productive sector which is the issue here. This calls for total commitment on the part of the universities to development through partnership with the SMIs.

1.5.4 The Role of Governments

It is apparent from the above that African governments should establish regulations, institutions and programmes for the promotion of SMIs. In Nigeria, for example, it is the policy of the government that low interest loans be made available to small-scale industries through the Nigerian Industrial Development Bank, the Nigerian Bank for Commerce and Industries and the Nigerian Directorate for Employment. This is a step in the right direction, although it is alleged that many of these institutions "discriminate against the small-scale sector in the sense that they measure loan capital by size of enterprise, which, in effect, excludes most small enterprises" (Landi J.H. and A. Diallo, 1988). Zimbabwe, Ghana, Zambia and many African countries have also established small-scale industry bodies for the sole purpose of promoting the development of small-scale industries. But even where attempts have been made to establish these agencies, programmes and incentives (generally financial, technical and managerial assistance) for the benefit of SMIs, these receive scanty governmental funding. The situation is

worsened by the fact that there is no effective coordination of the activities of the established agencies and programmes.

1.5.5 Donors and their Practices

It has already been noted that foreign aid is now the major source of funds for many African countries. Since many African countries have no choice, because other sources of international funding have dried up, it appears that no effort is being made by donors to untie aid. Consequently there is further weakening of African countries' ability to maintain clear cut policies. These policies are often distorted by activities of donor agencies, for example the purchase of inputs being tied to aid and the establishment of cosmetic programmes which are sometimes of little benefit to the African countries.

About twenty (20) development research donors provide funds for research in Africa. But, unlike IDRC, for example, most of the funds are used to support expatriate researchers or to strengthen non-national institutions. It appears that most donors have very little interest in or commitment to institution building for R&D in Africa (IDRC,1989).

1.5.6 The Problem

The entire African economy contributes less than 1 % of the total world production. But SMIs in many African countries continue to receive only the barest minimum of legislative, financial, technical and other assistance. The agencies, created in many African countries to promote SMIs, are ineffective and poorly financed. They have, therefore, been unable to make any significant change to the situation. This is further exacerbated by problems and constraints such as burdensome government procedures concerning registration, reporting, licensing and procurement of inputs, etc. Indeed, the entire environment, as outlined above, is unfavourable and often hostile to the development of SMIs. This obviously creates a very serious and unhealthy situation considering the fact that most African entrepreneurs, as noted earlier, are in the SMI sector. Again, there is no consensus on the nature of the new role for the universities, although there is general agreement on the

need for new directions. The problem is, therefore, simply this: given the above constraints and the environment in which the African universities operate, can they develop effective linkages with the SMIs? This is the central issue which this report seeks to address.

PART II: THE RESEARCH AND SERVICE NEEDS OF SMIs IN AFRICA.

Introduction

The research and service needs of SMIs in Africa embrace a wide spectrum of activities. This is simply because the SMIs in Africa have been neglected for so long a time that their needs have become overwhelming. Sometimes the policies of African governments are obstacles to innovation in the Small and Medium-Scale sector for the main reason that the actual needs of SMI are simply ignored. (Sverrisson, A.,1990).

Low capacity utilisation of industrial plants in Africa has been a persistent problem particularly of the medium-scale industries. In Nigeria, for example, it has been established that most manufacturing firms operate at about 47% capacity mainly because these firms depend on imported raw materials. (Fubara, B.A., 1987). It may not be possible to solve this raw materials problem in the short run, for all industries. It is, however, feasible to solve this problem for the majority of the small-scale industries.

Since SMIs are traditionally financially weak and are dispersed over all parts of the countries of Africa and they have a high potential role in creating employment for the rural community, and yet do not participate in the decision making process, the needs of these industries are important and must constantly be borne in mind by institutions with an interest in the promotion of SMIs. The universities, in particular, must understand fully the needs of industry. (Fishwick, W.,1983).

The needs of SMIs are traditionally finance, management, manpower and training in entrepreneurial reference skills. (Sverrison,A., 1990). In accordance with the terms of reference of this study these needs are categorised under four headings, namely research, service, finance and other needs.

2.1 THE RESEARCH NEEDS OF SMIs

2.1.1 Raw material identification and testing

The SMIs, as already noted, depend largely on local raw material supplies for their basic inputs. The identification of these materials, therefore, is of fundamental importance to the well-being of these industries. Even foreign owned SMIs, according to a study conducted in Kenya, tended to achieve significant results with respect to assimilation and further adaptation of product and process innovations aimed at increasing the local content of raw materials and at reducing reliance on expensive imported parts and components. (UNCTAD, 1987).

Some information on local raw materials exists in agencies such as Geological Survey Departments, Forestry Departments and the Ministries of Agriculture, among others. But this information must be repackaged in suitable and easily accessible form for the SMIs. In addition information on other sources of raw materials must be researched and supplied to the agencies which are set up to promote the SMIs. For example, agricultural wastes such as coconut fibre, palm kernel nuts, rice husks, etc need to be located, volumes or weights estimated and the time of the year when they are available determined for the benefit of SMIs.

Identification of the raw materials required by the SMIs is a first step. This step must be followed by careful testing and categorisation to ensure that they are suitable for use as raw materials for the manufacture of the intended product.

2.1.2 Product Development: Testing, Quality control and standardisation

The process of developing a product starts from the generation of an idea followed by the determination of the technical feasibility and the commitment of resources to the development of the product. The SMIs in Africa are either unwilling to commit the necessary funds, or are simply unable to provide the risk capital for such development. It follows that a university/research institution must undertake this function in the national interest. The Faculty Of Engineering in the University of Dar-Er-Salaam for

example, offers services in the field of material testing and quality control in its laboratories for SMIs. (Lwakabamba,S.B., and A.S.Bhandari., 1982).

Universities in collaboration with a National Standards Board, can also assist in standardisation and provision of advice on quality control. It is true that standards institutions have been set up in many African countries but these institutions have fairly well defined functions which do not include product development. They may not have the technological capacity and expertise to set up standards for all products. For example, a standards institution may not have the capacity to test or set up standards for traditional drug preparations - an important but often neglected product in Africa. In such a situation the testing may be assigned to, say, a pharmacy department of a university. This is one of the reasons why these standards institutions operate on the basis of expert committees.

Procedures for quality control are specific to a particular product or process. It follows that they must be researched into on the site and proper procedures clearly outlined for the day-to-day operations of the enterprise concerned.

2.1.3 Research into technologies

There is the urgent need to conduct research into technologies, including process improvements, adaptation of imported technology, upgrading of production systems, etc., appropriate to the needs of the SMIs. This is necessary in order to improve the operations of the SMIs to enable them survive in the current competitive environment. St. Lucia, a small island of about 400,000 people, once had a flourishing sugar industry which withered away due to obscelescence of technology. The country is yet to improve its sugar industry technology to enable its product compete on the world market. (Oragwu, F.N.C., 1990).

Although several different types of traditional equipment exist for the operations of SMIs it has been shown that these sets of equipment are inefficient. (TTC, 1990). They, therefore, need to be upgraded. Also the existing equipment manufactured locally appear to be comparatively too expensive and not very much

patronised and used by the SMIs. But they must be patronised by organised bodies, including the governments themselves. The Nigerian Project Development Agency, a Federal government institution, has developed a number of small-scale technologies, but most of these have not been commercialised. According to Prof. Fubara, "even the government that has set up this Agency ignores its own technologies for imported and expensive ones." (Fubara, B.A., 1987). It is necessary to conduct further research into the techniques and materials used in the manufacturing of such equipment, in order to reduce costs, but a conscious attempt must be made to commercialise the results using government procurement powers, among others.

There is also the crucial need to assess the local technologies, evaluate them and advise the SMIs accordingly. After the assessment and evaluation exercise, technology profiles and project profiles based on the viable and recommended technologies may be prepared and made available to the entrepreneurs. India, Yugoslavia and other countries are well known for their voluminous and useful technology profiles. Recently, the Economic Commission for Africa has also prepared a directory of project profiles for industries in the agricultural sector. (ECA, 1989h).

Many Third World countries, especially the Newly Industrialising Countries (NICs) have developed technologies which are appropriate to African conditions. There is the need to research into these sources and to adapt where necessary the imported technologies for use locally. The Technology Consultancy Centre, University of Science and Technology, Ghana, collaborates with intermediate technology groups in the USA, UK, Philippines, etc,in the search for appropriate technologies. The Centre itself develops technologies appropriate for the manufacturing of soap, leather bags, glue, metal products etc, for the SMIs. (Fishwick,W., 1983).

2.1.4 Assessment of needs and opportunities

In view of the low educational background of many African entrepreneurs in the SMI sector, these entrepreneurs can neither assess their own needs nor accurately define their problems. They are even unaware of the business opportunities in the SMI sector. The available economic opportunities must therefore be researched

and the results made available to them from time to time. Depending on the changes in the economy, the general and specific needs of SMIs must also be investigated and the findings made available to enable policy makers provide maximum and up-to-date support appropriate to the needs of the SMIs. The universities should research these needs to enable them fine-tune their research programmes for maximum impact. The close cooperation between the Institute of Production Innovation (IPI) of the University of Dar-Es-Salaam and the Small Industry Development Organisation (SIDO) of the Tanzania Ministry of Industry enables students to gather information on the needs of SMIs in the fields of production, manpower and equipment. The research activities of IPI are, therefore, designed to fulfil some of the real needs of industry. (Lwakabamba, S.B., and A.S.Bhandari., 1982). This activity by IPI is in the right direction. For, one of the main reasons why the results of research are irrelevant is precisely that the research bodies are unable to grasp the productive sector's demands for technology. (UNCTAD, 1988a).

2.1.5 Information needs

Many institutions have been established in African countries to promote the development of SMIs, but few of these have the time to collect and process information for the use of the SMIs. These institutions may not even be aware of the information needs of SMIs. But even if they are aware of these needs, they may be too busy with day-to-day operations and cannot attend to the information needs of SMIs. Information has now become a high-tech commodity with a high price since it is institutionalised in the modern information society.

The institutionalisation of information is even more important because of the need for innovative methods of processing and packaging information tailored for specific clientele. For example, the very innovative Technology for Livelihood Resource Centre in Manilla, Philippines has, in cooperation with the University of the Philippines, developed attractive manuals and instruction materials on audio and video cassettes and flat files on several simple small-scale technologies, such as flower arrangements, candle making, sewing and designing and electroplating, etc., for use in workshops and long-distance

instruction. But in the Sudan, it appears many researchers do not even recognise the need to be accountable for their research results let alone transmit same to users. (World Bank, 1985).

The ILO, which has been offering short-term consultancy and long-term technical assistance to some African countries, has realised that the activities of technology institutions hardly benefit the rural areas because the transferred technological information is either irrelevant to the needs of the rural areas or the rural areas lack the means to apply these technologies. (ILO, 1987). The ILO recommends that technology centres might assist in disseminating information to end-users. The universities should also assist in this effort.

The mission-oriented research into the information needs of SMIs must be directed towards the search for information on:

(i) local and foreign technologies which are viable and appropriate to the needs of SMIs,

(ii) bibliographical searches on specific products and processes,

(iii) market trends for SMI products,

(iv) dissemination of information on technological institutions and various events such as workshops, seminars, training, etc.

(v) government investment and other policies relevant t o the operations of SMIs,

(vi) credits available to SMIs and their sources.

(vii) government regulations concerning registration, taxes and operations of SMIs.

Some of the above information, especially (i), (ii) and (iv) may be obtained from ILO, UNIDO and other international institutions.

2.1.6 Contract Research

In view of the weak financial position of most SMIs, these industries are generally not able to enter into any contract research arrangements. It is well known that very few indigenous businesses do conduct in-house research let alone contract for research services for a fee. Contract research organisations such as the Korean Institute of Science and Technology (KIST) can only function well in an economic environment where SMIs thrive and prosper. (Hahn,S.J., 1989). Under the circumstances, therefore, there is the need for alternative and suitable forms of arrangements for many African countries.

One such arrangement is public financing of some researches directed at solving specific and common problems faced by SMIs. This is indeed the normal function of the publicly funded or government research institutions (within and without the universities). But this function is performed with greater efficiency if these institutions are formally and effectively linked to SMIs. This is a fertile area which the rich expertise, knowledge and experience of the universities in Africa should also be conscientiously invested with, to mutual advantage. Many research institutes and university departments in Africa engage in contract research.(see Appendix A). But the level of activity is too low to make any meaningful impact on the development of SMIs. This is understandable since, as stated elsewhere in this report, a major problem facing SMIs is that of finance for researches designed to benefit them.

2.2 THE SERVICE NEEDS OF SMIs.

2.2.1 Human Resources Development

The foremost need of the SMIs is in the area of human resource development. (Fishwick, W., 1983). Entrepreneurs are in need of trained manpower, continuing education for their employees and themselves, certification of skills and training in entrepreneurial skills.

Unlike the human resources required to operate large-sized industries, the personnel of SMIs require a large variety of skills.

This is complicated by the fact that these skills do not fall into recognisable professions. But there are many private and public educational institutions with experienced and competent staff who can train people to acquire these specialised skills to equip them to operate, maintain, test, or simply manage a small production outfit. But it is still important that the acquired skills, both in the technical and non-technical fields should be certified to be at levels in conformity with well laid down standards. In this connection, the members of the business, accounting, engineering, statistical,and other disciplines in the tertiary educational institutions have a crucial role to play in initiating schemes to ensure standardisation in those disciplines.

The essential manpower/education/training development schemes appropriate for the efficient and effective running of SMIs should embrace both traditional and special courses, tailored to suit the needs of the particular category of enterprises. The traditional courses include regular, certificate and diploma programmes. In view of changing needs brought about by both technological change and consumer preferences, it is important that tertiary institutions should be sensitive to these changes and adapt their curricula regularly, in consultation with industry. (Fishwick, W., 1983). This will ensure that SMIs keep abreast with technological changes, in order to maintain their comparative advantages as low cost generators of employment and suppliers of intermediate inputs to large-sized industries.

Education or manpower development in the traditional sense is not sufficient to raise the skills of the employees of SMIs. It is important to organise non-traditional and non-formal courses as a continuing development programme for employees to enable them update their knowledge, acquire additional skills or simply obtain additional paper qualification for the purposes of boosting morale or inspiring confidence in the employees. This continuing education must be organised by the educational institutions after due consultation with the employers and employees. It should consist of seminars, workshops, part-time day and evening studies and part-time graduate studies.

Finally, in the area of human resource development there is the need to pay attention to the training of entrepreneurs qua entrepreneurs. (ECA, 1989g). It is unfortunate that many tertiary

institutions do not pay attention to the subject of entrepreneurship training. This is simply because university teachers are by training not entrepreneurs. It means that the core of trainers in this field must be recruited from the private and or public business sectors. Here then is a case for linking the universities to the productive sector in order to take advantage of the experiences of businessmen. The courses can therefore be taught on part-time basis or carefully incorporated into existing curricula. Case studies are important sources of material for entrepreneurship training programmes. The universities, especially the social science departments, are in a unique position to prepare objective reports of actual cases for teaching purposes. Case studies can also be used:

(i) as the basis for the design of projects to be carried out by students.

(ii) as source materials for teachers to broaden their own outlook.

(iii) to provide potential entrepreneurs with what happens in the real world of business. (Fishwick, W., 1983).

In the area of management there is the need to train SMI entrepreneurs and their senior personnel in management techniques and labour relations. These, especially the former, are some of the key areas where the African entrepreneur is least competent. It is through training that the entrepreneurs in the SMI sector acquire new knowledge which inspires them to take higher risks.

2.2.2 Consultancy:

Consultancy is the most common form of assistance required by the SMIs. This is usually in the technical fields of engineering and economics. But the consultancy needs of SMIs are much broader, and should also include services in management and marketing. Advice on technical feasibility, plant design,plant layout and plant maintenance are important to the SMIs. In the economic area, the SMIs need assistance to prepare pre-feasibility and feasibility as well as accounting reports. As already stated marketing is another area where the SMI industrialist needs assistance. This assistance

could be in the form of market surveys or bulk purchase of the products to ensure regular income and production for the manufacturer. Indeed, it may be necessary to bulk purchase the items and export same on behalf of the producers. This function is normally performed by the export promotion councils established in some African countries. These councils have not been effective simply because they lack the resources to go into business in a meaningful way.

2.2.3 Socio-economic support

Two main socio-economic services are necessary to guarantee that the economic well-being of SMIs is sustained on a continuous basis. These are: (1) the study of the impact of macro-economic policies on the performance of the SMIs; (2) the evaluation and assessment of the various forms of assistance given to the SMIs. A study of the effect of macro-economic policies is imperative. The results of such a study should keep the government constantly aware of the influence of these policies on the operations of the SMI entrepreneurs. This is important since, as has already been noted, governments do generally give greater attention only to the needs of the large and medium-sized industries. (Harper,M. and Soon,T.T.; 1986).

Effective evaluation and assessment will enable the promoters of SMIs to get the needed feedback, as well as some measure of the usefulness of the services they are providing to the entire SMI sector. This socio-economic support must be provided on a regular basis to yield the desired dividends. An interesting socio-economic study was made by Ms. Selina Adjebeng who studied the social factors that influence the translation of innovation into entrepreneurship in post-harvest agro-industry in Nigeria. She isolated social factors critical to successful cumulation of innovation into entrepreneurship.

The evaluation of the socio-economic impact of alternative technologies, other socio-economic studies, etc., are more likely to be undertaken if the rural technology centres or the SMIs are well connected to national technology institutions such as the universities. (ILO, 1974). It is important to note here that KISTs success in Korea is due to the priority given to the needs of

clients through techno-economic studies such as the study of the status of important industries, future prospects and problems, etc,. (APO, 1989).

2.2.4 Technology Contracts

Contracts for the supply of technology normally in the form of know-how are often made by the medium-sized industrialists who lack the competence and expertise needed for these specialist tasks, especially for the specific purpose of acquiring the technology. These technology contracts involve substantive negotiation of the services being contracted for and the preparation of the agreement in a form acceptable to the foreign investments promotion centres in various African states. The experience in Africa is that in many cases negotiations do not actually take place at all. But rather the local technology recipient is sent a prepared agreement by the foreign technology supplier for the recipient's signature. This situation is unsatisfactory and invariably leads to the supply of equipment which is inoperable or the establishment of factories which are not viable even in the short term. In order to reduce this problem to the minimum, there is the urgent need to provide assistance to the SMI industrialists in their negotiations and drawing up of technology agreements.

2.3 FINANCE

Probably the most common and serious problem facing all indigenous industrial entrepreneurs in Africa is **finance**. This is not only because they have no collateral to secure loans but also because of distrust between the SMI entrepreneurs and the banking institutions. Furthermore efforts made by governments, admittedly with scarce resources, are rather feeble and not directed at implementing any identified programme. Even the few schemes designed to assist the SMIs are not well publicised. In the Philippines, the Bureau of Small and Medium Business Development (BSMBD) published and distributed a booklet on financing programmes for SMIs to achieve greater awareness among potential and existing entrepreneurs, and thereby ease the constraint against access to funds by the SMIs. (BSMBD, 1989). This booklet contains a large variety of financial schemes which is instructive in itself.

The few banks organised to assist SMIs, such as rural banks, have limited resources. In spite of these problems, it is in the national interest to launch well-planned programmes to assist the SMIs financially. This is a governmental function long recognised and accepted world-wide by all governments. Indeed, most services available to the SMIs are subsidised. Also the activities of international organisations such as the World Bank, UNIDO, ILO, FAO, etc, in the area of small business promotion must be researched and widely publicised so that the SMI entrepreneurs can take advantage of them.

2.4 OTHER SERVICE NEEDS OF SMIs

2.4.1 Dissemination of research results

Universities have resources in terms of high-level manpower and specialised equipment which are used in the conduct of research, leading to the production of research results. These results must be disseminated through the press, radio, television and other effective publication to enable the SMI entrepreneurs become aware of available new ideas, products and techniques. In this connection, it is necessary for researchers to liaise with industry and institutions with the responsibility for promoting SMIs. The lack of an effective machinery for continuous consultation between research and industry results in researchers being unaware of the needs of industry and this clearly limits the possibilities of marketing research findings. (UNCTAD, 1988b). In St. Lucia, one of the aims of the Manufacturers Association is to popularise the utilisation of locally-developed technology.

In Brazil, however, communication of research results is specifically recognised as vital to the success of research and an attempt is always made to train staff and establish units skilled in the reception and transmission of information. (World Bank, 1985). In Africa, in particular, there is the need to implement additional social communications systems, using local languages and audio-visuals to improve dissemination of research results. (IDRC, 1988).

2.4.2 Extension Services

Extension services are well developed for the agricultural sector but almost non-existent in the industrial sector. Even in the agricultural sector there is extension service for agricultural know-how but not for hardware. (Adjebeng-Asem, S., 1988). Industrial management and accounting services are required by the SMIs on a continuous basis and not only during the start-up operations. Many industrialists have difficulty in determining the causes of their stagnation or failure. It is, therefore essential that these industries are assisted in a timely manner through industrial extension services. But these services can only be effective if industrial estates are established with common services for the SMIs. Unfortunately, very few African countries have established industrial estates for SMIs.

Even in the absence of industrial estates, an alternative method of diffusing technology to SMIs is through Intermediate Technology Transfer Units (ITTUs) which in Ghana are operated by the Technology Consultancy Centre of the University of Science and Technology. These ITTUs consist of off-campus workshops designed and equipped to serve the needs of SMIs (mainly in the informal sector) through training and fabrication of machine parts. The ITTU is now recognised and have been adopted by the Ministry of Industries, Science and Technology, Ghana, as an effective mode of transfer of technology. (Smillie, I, 1986). There are currently plans to establish ITTUs in each region in Ghana.

2.4.3 Promotional Needs

Unlike the large-sized industries which have easy access to the services of the mass media and, more importantly, can afford to promote themselves, the SMIs are plagued with liquidity problems. The latter are therefore, unable to advertise their products effectively. Therefore offical bodies, advertising and public relations agencies set up to promote the interest of SMIs must make conscious efforts to promote the products and services of the SMIs. But many separate institutions (for credit, export promotion, extension, etc.,) are usually set up to promote SMIs in any one African country. There is the need to coordinate the work of these various institutions for effectiveness. (Harper & Soon, 1986).

Other institutions such as R&D institutes and universities may also assist in promoting SMIs and the formation and operations of formal non-governmental associations such as the association of small-scale industrialists. The Nigerian Association of Small-Scale Industrialists (NASSI), for example, is assisted in its work by the Nigerian Institute of Social and Economic Research. (see Appendix A).

2.5 SUMMARY OF RESEARCH AND SERVICE NEEDS OF SMIs

2.5.1 Research Needs

(i) Raw Material Identification and Testing
(ii) Product Development, Testing, Quality Control and Standardisation
(iii) Research into appropriate Technologies
(iv) Assessment of Needs & Opportunities
(v) Information Needs
(vi) Contract Research

2.5.2. Service Needs

(i) Human Resource Development
* special and short term courses
* traditional courses
* continuing education
* entrepreneurial training
* management

(ii) Consulting
* feasibility report preparation
* accounting
* marketing

(iii) Socio-economic support
* Evaluation and Assessment
* Study of impact of technologies
* techno-economic studies

(iv) Technology Contracts
* Negotiations
* Contract drafting

(v) Finance

* dissemination of sources & types of finance
* special programmes

(vi) Other Service Needs

* Dissemination of Research Results
* Extension Services
* Promotional Needs

PART III: STATE-OF-THE-ART REVIEW OF UPS LINKAGES

3.1 UPS LINKAGE STRATEGIES

The various strategies designed to effect unive_sity industry linkages are reviewed in this part of the report. It must be emphasised that there are no standard set of strategies. The strategies depend largely on the circumstances. it is, therefore, difficult to classify them. For the purpose of this report, the strategies are classified according to the purpose for which the linkage was set up. These are identified as:

(i) Research and Development (R & D)
(ii) Human Resource Development
(iii) Consultancy

Annexed to this report are briefs on selected cases on existing university productive sector (UPS) linkages. These cases are, where appropriate, referred to in this part of the report.

3.1.1 Linkages for Research and Development

The formal and informal linkages

Two main modes of linking universities to the productive sector for the purpose of solving industrial R&D problems can be discerned from the literature. First, individual departments or members of staff may be commissioned to undertake R&D activities on behalf of an industry for a fee. In such cases an informal group of university staff may be made responsible for the coordination and provision of information to inquirers. This situation prevails, for example, in the Chemistry Department of the University of Nairobi. Secondly, a formal unit may be established within or without the university to provide guidance and coordinate R&D activities being carried out on behalf of industry.

There are many variations of the formal unit as can been seen from the case studies (see Appendix A) and the following review of some of the strategies. Also these same strategies may be used for other functions such as human resource development or the

development of a sector and community generally. (see the Lahti Centre case, Appendix A).

In many countries centres have been established which create long-term collaboration between university and industry in research areas of mutual interest. For example, several Engineering Research Centres (ERCs) have been created by the National Science Foundation (NSF) of the United States government in US universities. These Centres are designed to encourage engineering research, *education & industrial partnership. In the University of Zimbabwe, a Timber Research Centre, equipped with modern machinery, researches into timber as a building material. (Sverrisson,A., 1990). Also, the University of Philippines at Los Banos has a Foundation, UPLBFI, supervised by the Vice-Chancellor, Academic Affairs, who has under him a Director of research. (see Appendix A).

Linkage with Private and Public Sector Firms

Private firms may also purposefully create institutional arrangements to foster university industry cooperation. A glowing example is that of the Pohang Iron and Steel Co. (POSCO)., in South Korea. POSCO created a new multi-disciplinary industrial research organisation and integrated it with a research-oriented educational institution in S&T. Thus Pohang Institute of S&T (POSTECH) and Research Institute of Industrial Science and Technology (RIST) were established. POSCO-RIST-POSTECH constituted a community with built-in tripartite industry-academia collaboration. (APO, 1989). Public sector firms, like the Indian Oil and Gas Commission, also do actively promote linkages with national research laboratories. In the case of, for example, the Indian National Council for Cement and Building Materials (NCB) the faculties of the Indian Institutes of Technology are involved in the formulation of the research projects. It is seen from the case studies (Appendix A) that some African institutions such as the TTC of the University of Science and Technology (Ghana) and FIIRO (Nigeria) have developed some linkages with the private sector firms mainly through contract research. Most of these linkages are, however, too informal. They need to be insititutionalised and strengthened.

Rural Development Centres

Again,in India, rural development is given a new direction and push through the establishment of Rural Development and Appropriate Technology Centres in several universities to address rural development problems which require technological solutions and also to work out modalities for technology transfer and feedback. Senior personnel of industry are involved as well as expert members of university committees which evaluate changes in curricula and new academic programmes.

The Technology Parks and Incubators

In many NICs and advanced countries, Technology Parks, Technopoles (Brazil), Hi-Tech Foundations or Incubators have been established and sited close to universities to forge university-industry linkages. In Malaysia, a Technology park was established in 1988 to provide facilities for academic and R&D personnel to commercialise high-potential research findings. Singapore has also set up a Science Park. This Park was set up by the Science Council of Singapore to forge university-industry relations in the area of high technology. Indeed, the possibility of such a linkage being established is one of the key criteria for approval of projects financed by the Council. The Singapore Institute of Standards and Industrial Research (SISIR), a large R&D complex, is housed in the Science Park. The proximity of SISIR to other hi-tech companies in the Park facilitates the sharing of equipment and ideas. (SCS,1988). In Brazil, the sharing of ideas and resources is encouraged through the networking of universities, industrial research institutes, R&D laboratories, etc,. It is worth mentioning here that the establishment of a hi-tech Science Park may be the result of a political decision. In Brazil, for example, the government established Telebras and located it near the University of Campinas for the purpose of developing endogenous capacity in the telecommunications field. The University of Campinas is heavily involved in this development through execution of contracts made with Telebras. (AAU, 1989b).

Research Consortia

In order to generate and diffuse technology more effectively, consortia are often established to conduct generic research of

interest to members of the consortia. Korea, India and Japan make extensive use of joint R&D programmes in generic technology areas to foster industry-university cooperation. In the University of Wisconsin's Centre for Product Exploration (Wisconsin, Madison) entrepreneurs are assisted to comprehensively solve problems associated with bringing a new product successfully to the market - from the idea stage through obtaining of venture capital (and sometimes to delivering the product to the user). The resources of Industry and the university are combined to help the entrepreneur.

In Brazil, a consortia of industries maintain a private university in the State of Sao Paulo by contributing 1% of their profits to the university. The Brazilian Federation of Industries also contribute to a large number of scholarships to enable: (AAU, 1989b):

(i) students go for attachment in any part of the country where they can best benefit from the training.

(ii) post-graduate students to undertake their theses research in industry on research and development projects.

The Committee System

The committee system is also often used to forge university-industry linkages. In Sri Lanka a national committee was set up in 1986 to promote university-industry linkages specifically in the field of chemistry . A university industry cooperative centre for technology was later set up at Moratuwa in 1989. Iran went a step further by ensuring that in each ministry and university there was an office responsible for developing university-industry linkages. (APO, 1989).

3.1.2 Human Resources Development (HRD)

There is a large number of and varied arrangements for the development of human resources. (Fishwick, W,, 1983). Four main arrangements are discussed here: the Teaching Company, Continuing Education, Cooperative Education, and industrial training.

The Teaching Company

First, The Teaching Company Scheme is often used to train personnel in, usually large, companies or firms in company premises with syllabuses designed jointly by the firm and the university to reflect the needs of the company. The training usually takes place at times convenient to the company employees, eg. evenings and lunch breaks. The Finnish example of the Nokia Corporation is a successful one. Nokia is a Finnish transnational company active in the production of computers, consumer electronics, telecommunications equipment, cables, rubber and paper with a turnover of over $5 billion and employing over 4,000 workers. Nokia mounted a comprehensive programme to upgrade the knowledge of its workers in 1987. Engineering, undergraduate and post-graduate courses were organised at a training centre established by NOKIA for the purpose and, more importantly, integrated with Nokia's own research projects and training needs. Courses take place during working hours and also during the worker's own free time. The Nokia Training Centre organises the training programmes in cooperation with the appropriate tertiary educational institutions and the workers. The contents of the training programmes are planned to suit the job assignment of each participant. This training takes place in Nokia's premises. The instructors are from the collaborating institute and experts from industry. The expenses of the training are covered by the Nokia Training Centre. This teaching company maintains close cooperation with industry and educational institutions for the development and execution of its programmes. (Sirkeinen,U., 1988).

Continuing Education

Secondly, through Continuing Education Departments established in universities for HRD, students sponsored by industry are admitted to universities on part-time basis to pursue special Master of Technology and other Diploma courses run for particular industries. In the Helsinki University of Technology, a Professional Development (PD) degree has recently been introduced. (Markkula, M., 1989b). Innovative artifices using information technology are also used for continuing education. An example is the Indian Institute of Technology (IIT), where films and video educational programmes are transmitted through troposcatter link at the (IIT) campus in New Delhi. Other universities conduct off-campus evening classes at

locations convenient to industrial workers. The Indian National Council on Cement and Building Materials (NCB) has established a centre for continuing education to train staff to meet specific needs of the industry. (APO, 1989). The University of Liberia, one of the oldest universities in Africa, has a division of continuing education with its own programmes and degrees. (Koon, T.G., 1987).

Cooperative Education

Thirdly, Cooperative Education, popular in the United Kingdom and elsewhere,and also known as Sandwich Courses, is also an effective mode of HRD. In this case industry releases workers for a specified period (for a day, week or a few months) to enable them take courses in the universities for credits toward a degree. The university works closely with industry to develop the courses and also establish the time-table.

Industrial Training

The most common form of cooperation between universities and industry is in the field of industrial training. It has been reported that about half the faculties in Africa insist on compulsory industrial training for their engineering graduates during the summer vacations, while for other graduates it is optional. (Fishwick,W., 1983). Virtually all engineering registration boards in Africa insist on post qualification practical training, usually for two years, before the young graduates are registered as professional engineers. But the main problem here is that the training, pre or post-qualification, is not properly supervised by many of the universities or the engineering registration boards. Some of the engineering registration boards do not have regulations to govern the type and content of the industrial training required for registration. Many universities in Africa do not have properly staffed offices to place students and also to follow up the training in industry. In Ghana, the Institution of Engineers has published details of the prescribed practical training and liaises with industry to ensure proper placement and compliance. The aspiring professional engineers are also formally interviewed to ensure that they have acquired the necessary practical training before admission into corporate membership of the Institution. (GIE, 1978).

Practical training is also useful for the university teachers. In Germany some technical universities have established a system of recruitment of staff which assures them of teachers with industrial experience. This system is based on a regulation in the technical universities and the faculties of Engineering which compels doctoral students to leave the university (after graduation) and seek employment in industry for ten or fifteen years. Some of these graduates are employed to teach in the universities after the ten-year experience in industry. (Aminu,J, 1987).

3.1.3 Consultancy

Consultancy is widely used as a generic purpose mechanism for reaching out to industry. A number of Universities have consultancy units which bear names such as Institute of Consultancy, Innovation Centre, Technology Centre,etc. But while some arrangements are informal, others are formal. The informal arrangements are on individual basis, generally the service provided is free or for a small fee. This is the commonest form of consultancy existing in many African universities. It is not effective.

The more common formal arrangement involves the establishment of a consultancy unit in a university staffed with full-time members of the university who do or do not teach. The scope may be wide, and may include research as well as feasibility report preparation, fabrication of equipment, assistance to infant firms, etc. In Africa since industries are unable to clearly identify their problems let alone pay for consultancy services, the usual arrangement is to subsidise these consultancy services by providing free staff time and the free use of equipment. In the Technology Consultancy Centre, Ghana, all the full-time staff of the Centre are paid by the university. In addition the university also provides some funds for other recurrent expenditures.

It is important to note that in the general area of consultancy students are active contributors to commercialisation of research results. These students generate technology through the conduct of research under the supervision of their professors and the transfer of technology through spin-off companies or employment with SMIs. In some countries (e.g. Brazil, USA, etc.) students have

founded companies for the commercialisation of the results of their MSc. project work. (AAU, 1989b).

Another mode of commercialisation is through patenting of research results. But this is not very popular or important in Africa since most of the technology required by SMIs for their operations are in the public domain. There may, however, be the need to adapt a patent system (eg. the utility model) in order to encourage the use of patent information and the generation of technologies which, although, non-patentable in the strict sense, may yet be of value to the economy of specific African countries. This will reduce the incidence of the findings of researchers being patented abroad by foreign research workers. This has happened to research findings in the area of pharmaceuticals in Senegal. (UNCTAD, 1988b). It must be emphasised, however, that the question of which patent regime is suitable for developing countries, especially African countries, is a difficult one. In fact the industrialised countries have made it clear, and are insisting, that the poor countries should adopt a strict patent regime to prevent the copying and imitation of products. (Ayiku,M.N.B.,1989).

In Brazil, Consulting Foundations exist in many universities. (There are also Technological Centres which specialise in specific disciplines and are responsible for cooperation with industry). The Foundations manage research contracts from industry. University staff usually receive salary supplementation from work in the foundations. In the University of Campinas, Brazil, the Director of the Foundation is also the Director of the Technology Centre. (AAU, 1989b). This is a very convenient administrative arrangement.

The University Liaison Office serves as a go-between, connecting the interests of both parties - university and industry. (OECD, 1984). This office usually provide information to industry on university facilities and expertise. A database is usually kept on nationwide R&D activities to facilitate the activities of the office and the general consultancy work of the university. Publication of non-technical information is also undertaken by the office. The office also assists in arranging industrial extension services. This is common within engineering schools in the USA.

3.2 COMMENT ON THE TYPES OF UPS LINKAGES

Among the R & D linkages, Individual and Informal R & D and the Committee Systems are the weakest but the common most linkages found in Africa. Research Centres, Foundations, Public or Private Sector Firm linkages, Rural or Appropriate Technology Centres and Research Consortia are uncommon in Africa but potentially useful UPS linkages. These linkages are not popular because both the governments and the beneficiaries (SMIs) are unwilling to adequately finance their operations. Probably the most promising R & D linkage is the Technology Park, Technopoles or Incubators. These practical linkages are multidisciplinary in nature and full of activities for any university professor interested in taking part in the execution of developmental project. This R&D linkage, which concentrates on high-technology areas in the advanced countries can be modified to operate as industrial estates designed to assist SMIs to start new businesses.

In the area of Human Resource Development, Industrial Training and Exchange of staff are the weakest linkages. The linkage, which is almost non-existent in Africa is the Teaching Company (TC). The reason for this situation is obvious: the SMIs are too poor to finance TC activities. The most promising linkage in the human resource development area is the Continuing Education Centre. This Centre is now seen by African universities as a money-making institution in this period of austerity. But they should be encouraged for the main reason that it is the major avenune for SMIs to acquire new knowledge or simply upgrade the old and at the same time enabling the universities to interact with tdhe SMIs.

Individual Consultancy, Spin-off Companies and Patent Licensing and University Liaison Office are three weak linkages in the Consultancy group of UPS linkages. It appears the promising linkage in Africa is the Consultancy Centre or Institute or Foundation. This UPS linkage will grow provided the Africa universities are prepared to be more committed to the promotion of this linkage.

Finally, it is emphasised that the above provides only an indication of the types of linkages appropriate to the African situation and, therefore, likely to make more contribution to

strengthening UPS linkages. Local conditions will certainly dictate the details and, indeed, the choice of the appropriate linkage.

3.3 ACTIVITIES OF INTERNATIONAL ORGANISATIONS IN PROMOTION OF UPS LINKAGES

Some international organisations are active not only in the promotion of the development of Small Scale Industries in the Third World but also in the area of university-industry linkages although the level of activity in the latter case leaves much to be desired. UNESCO, although actively pioneered the establishment of an international Association for Continuing Education in Engineering (IACEE) and has organised meetings and conducted studies on the subject of university-industry linkages. (see Fishwick, W., 1983). It has just set up a university-industry unit to coordinate activities and establish programmes in this field. It does not appear that any other UN agency has such a unit. UNIDO is also active. It is just about to offer technical assistance to the University of Addis Ababa to strengthen the university liaison office. UNCTAD, WIPO, ILO, - potential activists in this area - do not currently have definitive projects on the ground although the issue of linkages is sometimes indirectly discussed in their literature.

The European Community is very active in this area and it is promoting and effectively using these linkages as tools for European integration. Finally, IDRC has shown considerable concern for university-industry linkages in the entire Third World and has in fact organised, financed or sponsored several conferences, seminars, etc. (see for example, Azucena,C.F.,1988) and studies on the subject. It is clear that IDRC's concern is well founded since commercialisation of its research results in the Third World is moving at a slow pace. The assistance being given by IDRC regretfully is not making the desired impact. Probably a major reason is that there are no adequately equipped institutions with the necessary trained manpower to deal with commercialisation activities, especially in Africa.

In view of the above the AAU has an important task to sensitize the above institutions to devote more resources to the establishment of the institutional infrastructure in Africa which

will ensure effective university-industry linkages for their mutual benefit.

3.4 PROBLEMS OF FORGING UPS LINKAGES

Like any other human endeavour, there are several problems which plague UPS linkages. (Azucena,C.F., 1988; OSU, 1989). Some of such problems, considered important and peculiar to UPS linkages, are discussed here.

Deterrents to Linkages: From within the University

Firstly, it must be emphasised that activities undertaken in industry are multi-disciplinary in nature. They do not easily fall into separate water-tight compartments. Unfortunately, many universities, especially those in Africa, lack multi-disciplinary departments which can be relied on to play leading roles in UPS linkage activities. Industries, in both advanced and developing countries, are calling for a multi-disciplinary approach to the solutions of their problems. Since almost all the universities lack multi-disciplinary departments, they also lack the ability or the experience to work with other departments. This basic problem makes it difficult for UPS linkages to operate effectively.

Secondly, in addition to the weakness or the lack of interdisciplinary approach to solving problems, university teachers are traditionally not known to be entrepreneurs; they also have inadequate understanding of business practices and therefore are unable to communicate effectively with the business community. There are business imperatives such as the profit motive, schedule of deliveries, cost reduction, competitiveness, planning, etc., which, if understood and appreciated by university teachers, will greatly facilitate university industry relations and remove the accusation by industrialists that university research is too "theoretical" and not directed to solving the problems of industry. For example, some lecturers at the University of Science and Technology, Ghana designed a cookstove based on the use of sawdust as fuel. The main selling plank of the designers was that although the stove was expensive, the fuel, sawdust, was easily available in abundance and free. The designers did not take into consideration the cost of collecting the sawdust, the fact that sawdust is an

environmental nuisance in the home and, more importantly, the possibility that sawmills might impose a charge, once they realise that the sawdust has acquired an economic use. The stove is yet to gain acceptance by housewives. It is one of the many research results which policy makers describe as "research results lying on the shelf".

Thirdly, university policies and attitudes do not seem to encourage the establishment of UPS linkages. There is the major problem of universities finding it difficult to grant a UPS body the autonomy and flexibility it requires to carry out its functions. (Fishwick,W., 1983). Generally, UPS bodies located in African universities automatically adopt and apply university regulations relating to appointment of staff, promotions and remuneration for the running of their own bodies. Quite often university teaching and research staff do not fully appreciate the intensive work and high intellectual activity involved in UPS collaborative programmes. Thus they fail to accord such activities the full attention they deserve. In this connection it is instructive to repeat the words of Walter Murray, President of the University of Saskatchewan quoted in the 1900-1909 Annual Report of the university: (SCC, 1986):

> "the universities' watchword must be service to the State in all things that make for happiness and virtue as well as things that make wealth. No form of service is too mean or exalted."

Fourthly, non-recognition of the value of service to the community is noticed particularly in faculty evaluation and the assignment of teaching responsibilities. A staff member heavily involved in community work is not given a lighter teaching load, with the result that his work outside the campus suffers. Also traditionally universities rely heavily on academic publications in the evaluation of staff. Even though universities claim teaching and research as their priority responsibilities, rarely do universities' authorities take even the quality of teaching into consideration in the promotion of staff. In many of the advanced countries this is taken care of by the establishment of prizes for excellence in teaching.

Finally, university staff often argue that attributes of academic freedom, such as the free flow of information, and the

privilege to prosecute their own freely chosen research topics, are adversely affected by their involvement in industrial activities. It must however be noted here that academic freedom as propounded in the 1960s has seriously been truncated by developments such as the unwillingness of governments to provide universities with adequate funds for "pure" science or basic research activities. Indeed, it is the universities' search for other sources of income which has, paradoxically, drawn them closer to industry with the result that industry, especially those in the advanced countries, to a large extent, actively participate in drawing up the research agenda for academic staff engaged on collaborative Universities-Industry work. This is as it should be. But the universities complain that this is also affecting their freedom to publish their work on schedule in the interest of disseminating knowledge, since industrialist demand confidentiality and the exclusive right to commercialise the research results they have sponsored. It is submitted that in the African situation, the type of knowledge required for development is largely in the public domain. The problem is to assist entrepreneurs apply this knowledge effectively.

Deterrents to Linkages: From Industry

The main complaints against the African industrialists are, firstly, that they are unable to clearly define their problems hence their inability to benefit fully from university resources. (Aminu, J., 1987).

Secondly, the industrialists in Africa are generally unwilling to finance their own researches often citing liquidity problems and also that they do not derive immediate financial benefit from the research results or the technical advice. Thirdly, African entrepreneurs are anxious to import the latest technology without taking the trouble to find out what is available locally.

Fourthly, industrialists lack the essential information, which they claim, is exclusively within the knowledge of the universities. But even when this information is made available, many industrialists are unable to evaluate and, then, use it.

Fifthly, African industry does not perform in-house research, hence MSc or PhD graduates essentially do the work of technicians.

General

There are two general problems worth mentioning here. First, there is the problem created by the possible differential in salaries between regular university staff and UPS centre personnel. The trend elsewhere is that centre staff end up earning more than regular university staff resulting in internal conflict. This occurred, for example, in Stanford University (USA) a few years after the Stanford Research Institute (SRI) was established. The Board of trustees solved this problem by changing the status of SRI and making it an independent body of the university.

Secondly, there are problems created by the exodus of staff from the universities to industry in order to earn more money. Again, this happens because African industry now pays more to productive high-level manpower than universities.

The desire of professors at universities to earn more money, sometimes to the detriment of their main duties, creates a conflict of interest and duty which should be avoided. This calls for the recognition and design of mechanisms to control it. This is the function for the university councils in Africa.

3.5 BENEFITS OF INTERACTION

There are several potential benefits accruing from the interactions between universities and industry. (IDRC, 1988; Fishwick, W., 1983; OECD, 1984; Azucena,C.F., 1988). A few of these benefits of particular significance in the African context are listed hereunder.

(i) it bridges the gap between university and industry.

(ii) it enhances the image of the university, the staff and students.

(iii) it enables universities to adopt curricula that are more relevant to the needs of industry and society generally.

(iv) in time, and as industries develop, it will benefit the universities financially.

(v) it enables both university staff and students to acquire some industrial experience and awareness of societal problems as both work on real world problems of interest to industry.

(vi) the association of industry with the university enhances the entrepreneurial spirit of the entire community.

(vii) it serves the supreme societal function for which the universities were established: national development.

(viii) it encourages the use of local talent, raw materials and resources.

3.6 THE CASE FOR STATE INTERVENTION

The case for state intervention in the establishment of UPS centres is very strong. The fact that even in the advanced capitalist countries the state is heavily involved financially in the establishment of linkage centres on university campuses, for example, should suffice. But considering the poor premium on the development of S&T in Africa generally, it may be useful to restate some of these reasons. First there is need for the establishment of explicit industrial policy, R&D policy and new and dynamic educational systems in Africa, which will respond quickly to changing needs.

Secondly, the pervasive attitude of inertia, excessive bureaucracy and the propensity to import technology can only be addressed by the state through administrative rules and regulations and the introduction of appropriate fiscal and monetary policy to discourage unnecessary importation of technology and equipment, among others. The Malaysian government, for example, has introduced double tax deduction for R&D to encourage local initiatives.

Thirdly, there is the need for direct support to students for research in priority areas to reduce window dressing or display of

academic achievements that have little to do with pressing local industrial problems.

Fourthly, a strong engineering sector must be created to support commercialisation of R&D results. The absence of a clear policy in this important area is a major lacuna.

Finally, the resources required to effect linkages can only be provided by African governments or by international agencies (with support from the African governments). But the government's commitment and support must be explicit, clear and unambiguous. A glowing example is that of the establishment of the Technology Transfer Centre, Ghana. This Centre was formally (sic) established by the Government of Ghana in 1981. Several attempts made to secure the support of three UN executing agencies to assist in strengthening the Centre were unsuccessful. This was because some of the UN agencies did not fully appreciate the nature of the assistance being requested, ignored the request, or simply passed it on to another agency or the UNDP. There was no real government commitment until 1987 when it was made clear to the local UNDP by the Ministry of Finance and Economic Planning, Ghana, that the project on Technology Transfer was high on the government priority list and, therefore, must be financed from funds allocated to the country programme. The UNDP complied and signed, in 1988, a two-year agreement to finance the purchase of equipment, the training of local staff and the employment of local and foreign experts to enable the Centre conduct a series of policy research studies designed to strengthen the Centre's programmes and its linkages with S&T institutions (local and foreign). Within the two-year period, the Centre has produced over 20 reports, several occasional and technical papers and also organised workshops on technology transfer issues in Ghana (two of these workshops were organised with the active participation of UNIDO). This could not have been possible without a clear governmental intervention. (UNDP, 1988).

3.7 FUNDING

The main sources of funding for forging university-industry linkages, as stated earlier, are governments. In Korea for example, the Science and Engineering Foundation initiated a mission-oriented basic research programme in 1987 which brought together professors

and industrial R&D managers to prepare a detailed list of research areas suitable for academic research that industry considered vital to develop technology. (APO, 1989). The total funds for S&T in Korea increased steadily over the years. It increased over fourteen (14) times between 1970 and 1978. (UNESCO, 1985). Korea currently aims at spending over 2.5% of its GDP on S&T activities in the early 1990s.

Various countries are finding ways and means of using national S&T funds to strengthen UPS linkages. Malaysia recently established a new mechanism called Intensification of Research in Priority Areas (IRPA) for funding R&D projects. One of the important criteria used by the Central Research Panel of the IRPA to support funding for a research project is whether bipartite or tripartite linkages exist. (Omar,A.R., 1989, Said, A.M., 1989). Also, the Science Council of Singapore uses the same criteria for funding and admitting research groups into the Science Park of Singapore.

In some cases bilateral aid may be available.(These agencies include SAREC, IDRC, USAID, etc.). Thai's S&T Development Board (STDB) was established by a joint Thai-USAID fund to

(i) enhance the use of S&T in both the private and public sectors

(ii) to provide linkages between private industry and public R&D institutions.

In Ghana, the TCC receives about 25% of its project funds from external contributors, as against only 4% from consultancy fees. (Smillie, I., 1986).

Multilateral agencies such as the WORLD BANK, UNESCO, UNIDO, ILO, UNCTAD, etc. also assist by providing short-term technical assistance. But for operational projects assistance has to be sought from the UNDP. The UNDP is the " Ministry of Finance" of the UN system. It finances projects with funds from various sources but mainly from funds allocated to each Third World country for development - the country programme - by the UNDP General Council. This is one of the reasons why UN agencies, on receipt of requests for assistance, insist that the request must be endorsed by the

local UNDP office to ensure easy financing by the UNDP, mostly from the country programme.

African countries need not direct requests for assistance to the UN executing agencies in all cases. It is suggested that requests should be directed to the local UNDP office through the appropriate channels, usually the Ministry of Finance & Planning or Foreign Affairs. To ensure that adequate funds are made available for such an important activity as the development of linkages, it is further suggested that the universities should press their governments to allocate a specified proportion of the funds for the country programmes to S&T activities. An interesting case is Ethiopia where the UNDP funds are allocated to the various sectors by the government. Many academicians are not aware of the above facts. A case in point is that of an African university which applied for assistance from a UN agency immediately the linkage was inaugurated. It took four years for the university to be informed, after a Minister of State had appealed directly to the head of the UN agency, that a technical expert would be sent to determine their needs. Four years would have been saved had the Minister made the same appeal to the head of the local UNDP, or sent the request to the local UNDP for financing. Even if the funds for the country programme are already fully committed it is for the government to re-order its priorities in order to accommodate an important S&T programme such as the establishment of linkages for accelerating development.

It is also interesting to note that lack of linkages has recently been identified as one of the draw-backs of the IDDA programme. Accordingly, it has been planned that universities should play a role in the establishment of these linkages during the preparation and execution of IDDA II. The strategy for IDDA II calls for the design of integrated projects or programme approach. (ECA & UNIDO, 1989). It involves four basic steps: analysis of a sub-sector, definition of a strategy for development of the sub-sector, preparation of a package of integrated technical assistance and investment projects and definition of policies to implement programmes. The AAU has a clear promotional role to play. It also has the additional responsibility to research the sources of funding for university developmental activities and to create the awareness of their viability at the regular meetings of African Vice-Chancellors and at workshops and seminars in Africa. IDDA funds can

be used to forge linkages under IDDA II. There is the need to ensure that a university-industry unit is created within UNIDO for this purpose.

Donors are in the habit of unnecessarily delaying consideration of requests for funding of S&T projects to the extent that by the time the projects are finally approved, they have lost their significance. These delays which may be bureaucratic can be reduced or minimised if African governments establish clear S&T priorities and adhere to them. As it is now, inspite of the assistance being given by over twenty (20) donor agencies (bilateral, multilateral and foundations) to African countries, progress is very slow. There is, therefore, the need for the African governments to commit resources to S&T, especially for the establishment and operations of UPS linkages. For, as stated earlier, most of the donor agencies are not committed to institution building in Africa. Also, UPS linkages cannot take root or be effective in Africa without governmental interest in their operations.

3.8 SUMMARY OF TYPES OF UPS LINKAGES

3.8.1 R & D LINKAGES

(i) Individual & informal R & D
(ii) Research Centres, Foundations, etc
(iii) Public or Private Sector Firm Linkages
(iv) Rural or Appropriate Technology Centre
(v) Technology Parks, Technopoles or Incubators
(vi) Research Consortia
(vii) Committee Systems

3.8.2. Human Resource Development

(i) The Teaching Company
(ii) Continuing Education Centre
(iii) Cooperative Education
(iv) Industrial training and Exchange of Staff

3.8.3. Consultancy

(i) Individual Consultancy
(ii) Consultancy Centre or Institute or Foundation
(iii) Spin-off Companies and Patent Licensing
(iv) University Liaison Office

PART IV: CONCLUSIONS AND RECOMMENDATIONS

4. CONCLUSIONS

Before making specific recommendations on university-industry linkages, it is important to discuss briefly some of the implications of the cases. These relate, generally, to the factors which have contributed to render UPS linkages attractive to the universities, industry and government. (Cookey, S.J.S., 1987; Princewill,G.B., 1987), and the characteristics of the forms of cooperation derivable from the case studies.

4.1 ESTABLISHMENT OF UPS LINKAGES: THE ECONOMIC AND OTHER IMPERATIVES

The reduced financial support for universities, balance of payment and other economic problems oblige governments to encourage UPS linkages for the benefit of society. In India, for example, government financial support for all public research institutions was reduced by 30%. These institutions therefore have to earn 30% of their incomes from non-governmental sources. In the search for cost-saving strategies, many universities have found that employment of part-time teachers from industry is cost-effective. In Holland, for example, the proportion of part-time staff in the universities is about 20%.

Shortage of hard currency to import products, spare parts etc., and international competitiveness have compelled industry to look to the universities for innovative ideas, improvement of production processes and quality of goods and the development of human resources appropriate to the needs of industry. The universities are also anxious to modify their programmes to make their products (and themselves) more competitive and marketable in the education market, hence the desire to improve university resources (equipment, courses, staff, etc.) to make these attractive to industry and new students.

In their attempt to attract the cooperation of industry, some universities have created structures to involve industry in the review of course structures and content, the determination of R&D

policy and exchange of staff. There is thus regular communication and interaction between university staff and industry personnel.

The immediate and profitable industrial application of R&D results in new fields, such as biotechnology, genetic engineering and other knowledge-intensive technologies, have blurred the distinction between basic research and applied research and thereby made university research very attractive to modern industry.

The desire of donor countries to tie aid to procurement of goods and services (including research and consultancy by university staff) have encouraged universities in donor countries to establish institutes and centres ostensibly to facilitate cooperation with developing countries, but in reality they are designed and operated to strengthen their own resources and also enable them assess the needs of the developing countries for the purpose of increasing their exports to those countries.

The "power of the purse" is used indirectly in many countries to compel universities to cooperate with industry. In Singapore, grants to R&D firms are conditioned on the possibility of the proposed project forging bi-partite or tripartite cooperation.

4.2 CHARACTERISTICS OF THE FORMS OF COOPERATION

Inspite of the multiplicity of forms of cooperation, there are distinct characteristic features of Effective and Loose linkages. (Cookey, J.S., 1987). The effective linkages are found in most industrialised countries. The loose linkages exist in almost all African countries. The NICs have recently taken steps to strengthen their UPS linkages. Most NIC UPS linkages, therefore, have some sort of a combination of some of the characteristics of both Effective and Loose UPS linkages.

4.2.1 Characteristics of Effective UPS Linkages.

Effective UPS linkages are characterised by:

(i) Financial involvement of industry (long term grants, R&D contracts, endowments, establishment of professorial chairs, etc.)

(ii) Establishment of several permanent UPS structures (centres, institutes, foundations, liaison offices, etc.) to serve SMIs and also for regular communication with industry in those areas of strategic importance to industry or the country which each institute or centre is mandated to promote. At the same time a careful balance between academic freedom and economic realities of the times is maintained.

(iii) The commitment of the university leadership to change by ensuring flexibility in operational rules and the autonomy of the UPS linkages and the personal commitment of the heads of the UPS linkage centres.

(iv) Fostering of an informal human network of scientists and industrialists, and the physical closeness of resources and facilities. (siting of significant projects such as Science Park, specialised research institutes, etc., near the university).

(v) Government encouragement by providing resources and creation of enabling environment for commercialisation of research results and, generally, the establishment of effective S&T policies and institutions.

(vi) Matching of the assessed needs of SMIs to university resources.

4.2.2 Characteristics of Loose UPS Linkages.

Loose UPS linkages are characterised by:

(i) University's resistance to effective structural changes and lack of commitment to the establishment of effective UPS linkages.

(ii) Establishment of weak or temporary linkages with industry mainly on the personal level (conferences, individual consultancies, student attachment, etc.)

(iii) Weak and poorly funded centres with little or no autonomy.

(iv) Insignificant government involvement (poor funding, poor enabling environment for commercialisation of R&D results and unwillingness to use the "power of the purse" to encourage the establishment of UPS linkages).

(v) Poor science culture and weak S&T policies and institutions.

(vi) Insignificant income to the university from consultancy and, generally, from industry.

4.3 RECOMMENDATIONS

4.3.1 General

The AAU should seek technical assistance from NIC experts to undertake the analysis of some country characteristics and needs so as to build up country specific linkages. This task must be performed with the full cooperation of heads of selected universities in Africa.

4.3.2 Awareness Creation and Promotional Activities.

(a) The AAU should organise an all African regional conference to discuss relevant issues such as: establishment, funding sources for UPS centres and relevance of programmes such as UNIDO's IDDA II.

(b) Trade fairs and exhibitions, should be organised by the AAU in cooperation with national professional associations. Appropriate prizes must also be instituted and awarded at the exhibitions or fairs.

(c) The AAU should organize national workshops (with support of top government officials) to identify needs and problems, assess capabilities to develop linkages and examine what that country can do to realise effective UPS

linkages. The universities must be fully involved in this exercise.

(d) The AAU should organise study tours for designated or serving UPS centre directors to accelerate the transfer of the technology for the management of UPS centres.

(e) The AAU should create an information Bank of UPS linkage activities in Africa and regularly monitor these activities with a view to promoting the interests of the UPS centres.

(f) The AAU should facilitate the establishment of rules and regulations to govern the operations of UPS linkages in selected African universities.

(g) The AAU should use its good offices to begin a world-wide effort to persuade key organisations such as WHO, FAO, ILO, UNIDO, UNCTAD, African Development Bank, etc. to create university-industry units or desks within their organisations to facilitate UPS activities in Africa.

4.3.3 Continuing Research

There are several compelling reasons why the AAU should mount research into UPS linkage establishments on a continuing basis. Firstly, the problem of UPS linkages has a unique African flavour. Few organisations outside the African continent are likely to understand and appreciate some of the developmental problems of the continent mainly because these problems are firmly bound up with African traditions and culture. Cultural change can only be promoted from within. The initiative must necessarily be taken by African institutions - and later supported by well wishers outside the African continent. No country, it is said, can develop outside its own culture. Also no cultural change can be imposed from outside.

Secondly, it is well known that foreign bilateral institutions are not willing to finance S&T projects of this nature in Africa. The AAU being an international institution may, therefore, liaise and cooperate with multilateral and other institutions such as the

UN system, IDRC, DANIDA, SAREC,etc. to bring about that type of cultural change which will promote meaningful development of the continent. This may even involve the AAU in activities of a political nature, especially within the OAU and ECA.

Thirdly, the AAU should use its unique position to mount interdisciplinary research programmes to bring together both S&T and social scientists for the development of the African Continent.

Specifically, the areas of research include the following:

(i) Criteria and standards for measuring achievement

(ii) Assessment of the impact of the technology developed and diffused

(iii) Study of the UPS Linkage organisation forms and management

(iv) Evaluation of locally developed technology prior to commercialisation

(v) Sources of Funding

APPENDIX A: CASE STUDIES

LIST OF CASES

1. **AFRICA:**

A1: Addis Ababa University Cooperation Programme
A2: Emerging New Structures in Nigerian Universities
A3: Technology Consultancy Centre (TCC), Kumasi,Ghana
A4: University of Nairobi, Nairobi, Kenya
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A6: Ecole Nationale Superieure Universitaire de Technologie (ENSUT),DAKAR.
A7: Regional Research Centres, Egypt
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2. **THE AMERICAS:**

A9: Engineering Research Centres (ERCs), USA
A10: Engineering School, University of ZULIA, Venezuela
A11: Monterrey Institute of Technology (ITESM), Monterrey, Mexico
A12: Opening of National Research Laboratories to the Public, USA
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3. **ASIA:**

A14: Chula Unisearch - Chulalongkorn University, Thailand
A15: Singapore Science Park
A16: Uniserv Chiangmai University of Thailand
A17: The University of Philippines Los Banos Foundation, Inc. (UPLBFI)
A18: Chinese Academy of Sciences : Spin-off Companies.

4. **EUROPE:**

A19: Helsinki University of Technology, Finland
A20: The Industrial Researcher Education
A21: The Lahti Centre, Finland
A22: The Teaching Company Scheme (TC), United Kingdom
A23: The IDEON Complex, Sweden

5. INTERNATIONAL

A24: COMETT - Community Action Programme for Education & Training for Technology of the European Community

A25: The ERASMUS Programme - (EEC)

A26: The International Association for Continuing Engineering Education (IACEE).

A27: Cooperation between Engineering Colleges & Industry in South East Asia

CASE STUDIES

1. AFRICA:

A1: ADDIS ABABA UNIVERSITY COOPERATIVE PROGRAMME

This programme was established by the University of Addis Ababa and the Ministry of Industry, Ethiopia, in 1986 to forge closer cooperation between Industry and the University. The agreement created three organs of the Cooperative Programme: The Policy Committee, the Executive Committee and the Liaison office. These bodies are respectively responsible for overall policy direction, day-to-day supervision of the activities and execution of programmes. Both the Liaison Officer and the Secretary work on part-time basis. The objectives of the Cooperation Programme are to promote joint R & D activities, develop human resources for industry and enable both staff and students of the University gain practical industrial experience. The programme is largely financed from a joint fund created through mandatory and voluntary contributions from industry.

The above programme is not successful for the reason that industry is not fully committed to the programme and also because the office is structurally defective in its management as the principal officers work on part-time basis. No wonder, therefore, that the office has applied to UNIDO for assistance to put the programme on a proper footing.

A2: EMERGING NEW STRUCTURES IN NIGERIAN UNIVERSITIES

The Nigerian Universities Commission, established in 1962, is an independent department of the Cabinet Office of the Federal Government of Nigeria. All funds for disbursement to the Universities by the Nigerian Federal Government are channeled through the Commission. Thus the Commission acts as a Universities Grants Commission. As a result of the global recession that has affected the Nigerian economy, the level of funding to the universities has substantially declined. In particular, funds for teaching and research equipment declined by about 30% between 1986 and 1987.

The Executive Secretary of the Commission has recently advised the Vice-Chancellors "to look for ways of reducing costs and generating income." The suggested income generating activities include organisation of seminars, short courses, diploma and part-time programmes and continuing education. Some of the universities of Nigeria have responded by creating new structures to cope with the situation. Among the new and emerging structures are: (AAU, 1987):

(i) consultancy services to government agencies, industry and private enterprises.

(ii) cooperative ventures with industries, including equity investments, research funding, endowments, licenses, etc.

A3: TECHNOLOGY CONSULTANCY CENTRE (TCC), GHANA

The University of Science and Technology (UST), Kumasi, Ghana, is one of the three universities offering degrees in scientific disciplines in the country but the only university offering degrees and diplomas in engineering and technology. The TCC is a formal establishment, set up by the UST in 1972, to serve as a clearing house for passing enquiries from industrialists onto the faculties of the university. But this function proved too narrow for the extension work that was needed to satisfy the demands of the SMIs. Presently the centre offers technical service and advice to industry. It seeks to upgrade existing SMIs by:

(i) introducing new products and manufacturing techniques.

(ii) generating small-scale industries, using as far as possible local raw materials.

(iii) exposing would-be entrepreneurs to production techniques and problems by exposing them to pilot plant production units set up on the university campus and operated by the TCC.

(iv) introducing technologies appropriate to the needs of SMIs.

Consultants from the faculties on specific projects are paid 70% of the net profits, the remaining 30% is shared equally between the Centre and the consultant's academic department.

The university pays the recurrent expenses of the Centre but the bulk of the capital expenditure of the Centre comes from consulting fees and outside sources. (Fishwick,W., 1983).

A4: UNIVERSITY OF NAIROBI, KENYA

In Kenya engineers are trained in the Faculty of Engineering of the University of Nairobi. The training offered by the faculty provides graduates in engineering with a good theoretical background. To supplement this training and also enable the students obtain some practical experience before graduation, the second-year students are expected to obtain employment with engineering firms during the three-month long summer vacation before embarking on their third and final year of their course. Experience has shown, however, that the students do not obtain this type of employment and the practical training that goes with it. One reason is that the existing course lacks the necessary practical dimension, which would make the students attractive to engineering employers.

To rectify the above deficiency, the Kenya Engineering Registration Board insists on three years practical training in industry before a graduate engineer is registered as a professional engineer. Unfortunately many employers are over anxious to get immediate work output from the young graduates and neglect their

training needs. This is due largely to the fact that there is lack of an efficient mechanism for monitoring practical training of young engineers in industry. In fact, there are no regulations established by the registration board to ensure that engineers do get the required practical training in industry. Both the Institution of Engineers in Kenya and the Engineering Registration Board are aware of the above problems and are making efforts to address them. (Fishwick,W., 1983).

A5: UNIVERSITY OF DAR-ES-SALAAM, TANZANIA

The University Dar-es-Salaam, is the only university in Tanzania. The university was established in 1970. One of the functions of the university as stated in the Act of 1970 is "to prepare students to work with the people of Tanzania for the benefit of the matter". This is indeed an admirable objective.

The university seeks to implement this mandate by establishing linkages with industry and the public sector. The main vehicles for this linkage are the Engineering Faculty and the Institute of Production Innovation both established with the assistance of the Federal Republic of Germany. (Lwakabamba S.B. and A.S. Bhandari,. 1982).

(i) Industrial Training

Students pursuing the four-year engineering course are required to spend three periods of two months' practical training in industry. Laboratory project work and field practicals are integral components of the regular course. The industrial training is considered a continuation of the workshop training offered to all students early in their university course.

(ii) Service

The faculty offers services in the field of material testing and quality control in its laboratories for SMIs. The manufacturing, repair and fabrication of various components are also undertaken in the faculty.

(iii) Consultancy

Requests from industry for consulting, design, etc. are handled by faculty members. These include the design of sisal harvesters, study of vehicle load regulation for the Tanzania-Zambia Highway, solution to landslide problems along the Tanzam railroad, etc. The faculty is rather disappointed that engineers in industry resort to expatriate consultants to solve complicated and challenging projects instead of referring same to the faculty as consultancy projects.

(iv) Research

Research is carried out by faculty members on projects of relevance to national development. These include research into sisal fibre reinforced concrete, biomass conversion, solar energy applications and hydraulic flow characteristics of bamboo and woodstave pipes. Some of these researches are carried out as part of higher degree studies.

(v) Office of Relations with Industry (ORI)

The ORI was established as part of the Dean's office to co-ordinate practical training of students and also to assess the qualitative engineering manpower requirements of industry.

(vi) Continuing Education

The Faculty runs seminars for practising engineers. These have proved popular and, therefore, successful. In addition, the faculty has established a post graduate master's degree engineering programme tailored to suit the needs of professional engineers in Tanzania.

(vii) The Institute of Production Innovation (IPI)

This Institute was established about ten years ago with the help of the Federal Republic of Germany. The IPI is a direct result of the critical assessment of the needs of Tanzania Industry by the Faculty of Engineering, production firms and the Ministry of Industry.

The functions of IPI include:

(i) Development and design of pilot plants on request from SMIs or as a result of national needs as spotted by the IPI through its research activities.

(ii) Production of items for sale to generate income.

(iii) Consultancy services to firms on request. IPI works closely with the Small Scale Industry Development Organisation (SIDO) of Tanzania.

SIDO's functions include:

(a) surveying resources.

(b) providing machines to small scale industries on hire-purchase, and

(c) dissemination of technical know-how.

The transfer of technologies developed by IPI is carried out through SIDO.

It is important to note that the close cooperation between IPI and SIDO enables students to gather information on the needs of SMIs in the fields of production, manpower and equipment. The research activities of IPI, therefore, fulfills some of the real needs of industry.

A6: ECOLE NATIONALE SUPERIEURE UNIVERSITAIRE DE TECHNOLOGIE (ENSUT), SENEGAL

ENSUT is a multi-purpose training facility designed to provide Senegal's industry with senior technicians and engineers suited to local requirements. Industry is represented on the ENSUT governing body. In addition to providing training, ENSUT carries out a variety of research activities in two principal fields:

(i) utilization of natural substances, including the production of fertilizer from groundnut shells and

sugar-cane molasses, the conservation of leguminous plants, the conservation of tropical fruits and the production of methane by a fermenting process using the contents of the rumens of bovine animals or domestic refuse, and

(ii) development of renewable energy.

ENSUT does not have its own budget for research. However, 10 per cent of its operating budget is earmarked to finance research activities. Since this sum is small, ENSUT submits specific projects directly to foreign sources of finance.

The teaching staff consist of 100 teachers, 75 of whom are engaged in research.

ENSUT provides other services such as:

(a) technical assistance in quality analysis and control

(b) training of technicians some of which takes the form of actual supervision of the work of promoters, designers or managers of SMIs.

(c) provision of advice to small enterprises on the launching of new processes or products

ENSUT does not disseminate its research findings - a serious deficiency which has handicapped the work of ENSUT. (UNCTAD, 1988b).

A7: REGIONAL RESEARCH CENTRES, EGYPT

Egypt is one of the few countries in Africa with an extensive S&T network supervised by the Minister of Scientific Research. Egypt in 1987 spent about 1.2% of its GDP on R&D. An interesting new feature of its R&D linkage with the productive sector is the establishment of Regional Research Centres.

These Regional Centres are the interlinking mechanisms between the S and T community on the one hand and the planning and

implementation of regional socio-economic projects on the other. The Regional Research Centres, were established by the Academy of Scientific Research and Technology (ASRT) in 1983. The ASRT is the central body responsible for S&T in Egypt. These Centres, which are intended to cover all eight planning regions of the country, are expected to be the focal points for interaction among regional universities, regional planning authorities and production and service sectors. They are considered to be the S & T arm for local governments. ASRT is responsible for the management and co-ordination of these institutes with the Egyptian National S & T Information Network. Three of these Regional Centres started operations in 1986 and the others are at various stages of establishment. (UNCTAD, 1988a).

A8: NIGERIAN ASSOCIATION OF SMALL SCALE INDUSTRIALISTS (NASSI), NIGERIA

The NASSI was established in 1978. It became an effective national association only a couple of years ago. According to the Director-General of the newly created Federal Ministry of Science and Technology the small-scale industries form the industrial backbone of the economy. The small-scale industrialists are therefore taken seriously by the ministry. To demonstrate this serousness the association serves on committees of the ministry (such as the Committee on Technology Business Incubator). The ministry also exposes the members of NASSI to technonological and trade fairs abroad, among others. The current membership of the Association is over 15,000 small-scale industries (in all the states in Nigeria and the Federal capital, Abuja), classified into eight broad categories including food processing, rubber and plastics, paper, etc.

The objectives of NASSI are:

(i) To establish and maintain an Association for the exchange of ideas and techniques on issues relevant to the development of small and/or medium scale industries in Nigeria.

(ii) To establish channels of communication with government and governmental institutions, financial institutions,

employment Bodies and other manufacturing organisations for the purpose of securing loans, properties or other assistance in the advancement and development of small and/or medium scale industries.

(iii) To promote business education programmes through organised seminars, symposias, workshops, lectures, trade fairs, conferences, debates, dialogues and other public enlightenment programmes.

(iv) To contact, consult, confer and co-operate with organisations and persons in Nigeria or elsewhere having objects in parts or whole similar to those of the association.

(v) To engage in activities that are conducive to the promotion and advancement of the Association.

The Association provides the following services:

(i) Information on Raw Materials Sourcing.

(ii) Information on Plant and Equipment

(iii) Information on Manufacturing Standards.

(iv) Training Programmes on
   a. 'Working for Yourself' (WFY)
   b. 'Small Business Management (SBM)
   c. 'Improve ;Your Business' (IYB)
   d. 'Business Plan and Financial Management' (BPFM)

(v) Counselling

(vi) Library services for Small and Medium Scale Industrialists.

(vii) Small Scale Business Technologies

(viii) Organisation of periodic seminars, workshops, conferences, symposia, study-tours, dialogues, public lecturers, trade-fairs etc.

NASSI is well connected in Nigeria. In addition to enjoing the confidence and support of the Federal Ministry of Science and Technology, the association has the Federal Institute of Industrial Research, Oshodi (FIIRO) as a member and receives technical assistance in its training and other programmes from the Institute for Social and Economic Research (NISER) and the FIIRO, among others. The association cooperates with an impressive array of over fifteen institutions in Nigeria including the Federal Ministry of Industries, the Nigerian Bank for Commerce and Industries, National Productivity Centre, etc. and international organisations such as the ILO,UNIDO, UNDP,British Council and the Friedrich-Erbert Foundation (FEF).

The NASSI publishes a quarterly NEWSLETTER titled 'THE SMALL SCALE INDUSTRIALIST' as a medium of information dissermination to its members. The newsletter is edited by NISER in collaboration with NASSI. There are also the Economic Dialogue (sponsored by FEF) and the National Directory which is published annually by NASSI.

2. THE AMERICAS:

A9: ENGINEERING RESEARCH CENTRES (ERCs), USA

The two institutions of the US Government responsible for launching the Engineering Research Centres (ERCs) in 1985 were the Office of Science and Technology Policy and the National Science Foundation (NSF).

The Centres which are cross-disciplinary engineering institutions with strong commitment to: (i) engineering research (ii) education and (iii) industrial partnerships are located on the campuses of universities.

The objectives of the centres are: (a) to have a major impact on the educational system and be responsive to long-term industrial issues; (b) to provide linkages and bring together the capabilities and resources of the government, universities, and industry; (c) to develop individual relationships with industry consistent with given local government; (d) to provide new knowledge and innovative ideas in areas of concern to industry.

The ERCs/NSF Programme therefore focuses on (a) applied research and interdisciplinary collaboration in the successful reduction of scientific discovery to practice; (b) development of fundamental knowledge in the engineering fields to enhance international competitiveness of US industry (c) education and production of engineers to contribute, through better engineering practice, the improvement of design of technological processes and devices etc.

In addition to encouraging industrial support, NSF invests heavily in supporting the cooperative research proposals submitted by universities and accepted for implementation on collaboration basis. NSF funding is normally provided for 5 years subject to renewal on the basis of satisfactory peer review.

In 1986 the scope of ERCs activities involved eleven (11) Centres in operation. NSF's goal was to establish 25 ERCs. Industrial support and participation involves a large number of industries (141 companies). About 11 Universities are also participating in the cooperative projects.

ERCs/NSF Programme has tremendous beneficial effects:

(a) By concentrating on R & D projects in particular areas of industrial and national importance, the Centres provide cross-disciplinary research opportunities for faculty and students to contribute to fundamental knowledge.

(b) Opportunities are also provided for engineering graduates to be trained within the frame-work of system aspects of quality engineering urgently needed by industry.

The Programme achievements are summarised below:

It has:

(a) provided major avenues for collaboration between industry and universities

(b) created capabilities for cross-disciplinary approaches to engineering problems

(c) provided a link between theoretical and experimental approaches to the solution of problems that are important to the US

(d) improved the working relationships and cooperation among practising engineers, faculties and students and has acted as effective forum that introduces students to the synthesis, integration and management of engineering systems.

(e) raised the interest of universities in the ERC concept as reflected in the large number of proposals they usually submit for consideration by NSF.

(f) generated tremendous interest outside the NSF System, and has become a MODEL for many domestic and international efforts.

(g) in the international arena, attracted exceptionally high interest and attention from foreign governments in their efforts to build effective institutional linkages in their own national technological endeavours.

Lessons: The ERC concept - its success - shows that universities can play a significant role in technology creation, and at the same time maintain their traditional role in science creation. (Badawy,M.K., 1989).

A10: ENGINEERING SCHOOL, UNIVERSITY OF ZULIA, VENEZUELA

The School places emphasis on research work during the professional stage in the training of the undergraduate student. This is accomplished by completing a thesis involving work on some research topic under the supervision of a professor-adviser. Final year students choose their research work topic from those presented by the local industries themselves as troublesome areas. Also the student follow a 12 week internship programme at any local or national industry. During the internship the students deal with field techniques, or problem-solving activities in their specialised fields. (Cendros,J. and L. Ricon., 1989).

The undergraduate thesis research work and internship have reached great acceptance level among industrial managers and university teaching staff because they have been recognised as an appropriate answer to problem-solving at a very low cost.

The School of Engineering has created the following Offices at the school for the purpose of establishing and coordinating effective LINKS with local industry:

1. **The Education - Industry Office (Liaison)**

   (a) coordinates everything dealing with internships at the local industries.

   (b) organises meetings with industrial managers to determine the quota of students to be accepted for internship and research projects.

2. **The Engineering School Technical Office (Consultancy)**

   (a) promotes projects for problem-solving at the local industry;

   (b) has a managerial character, and functions as an engineering- consultancy centre.

3. **The Office for Continuing Education.**

   organises courses aimed at professional improvement of engineers and personnel working at local industries.

A11: MONTERREY INSTITUTE OF TECHNOLOGY (ITESM) MONTERREY - MEXICO

I. The High Technology Centre for Production - (ITESM System)

In accordance with its mission and priorities the Monterrey Campus established the High Technology Centre for Production as part of its ITESM System to do research and develop human resources in areas of high priority for national development.

The Centre, which comprises eight research institutes, was built and equipped with support from industry. It focuses on areas devoted to:

(a) the manufacturing and management technologies for producing high quality products at low cost to compete favourably in the international markets

(b) the State of the art technologies of strategic importance

(c) the enhancement of graduate programmes.

II. Continuing Education

The ITESM system of the Monterrey Institute of Technology also develops and organises programmes for **Continuing Education** -

(a) to keep professionals up to-date in their fields and

(b) to provide specialised training courses for top officials/ executive in the community in Quality Control, Manufacturing Project Management, Advanced Business Administration, International Competitiveness, Marketing etc.

III. The ITESM system also provides specialised Senior High School Education to expose adult students to its undergraduate programmes (Adult Education). (OSU, 1989)

A12: OPENING NATIONAL (FEDERAL) RESEARCH LABORATORIES TO THE PUBLIC [USA]

About 3/4 of all R & D work in the USA is performed by industry. The remaining 1/4 is divided among university, government and other non-profit Laboratories. The Industrial Laboratories therefore play a central role in the nation's R & D effort not only in product development but also in applied and basic research. (Badawy, M.K., 1989).

Opening the Federal Research Laboratories to the public is an effective and successful means adopted at the national level to foster cooperation among government, industry, and universities for enhancing the nation's capacity to innovate technologically.

The opening up of the national (Federal) laboratories have been motivated by several considerations. The important ones are:

1. They are large facilities built with public funds to carry out advanced research and technological development.

2. They have been made available to the technical community in order to (a) minimise duplication, (b) promote beneficial interaction and (c) make the most effective use of large, costly and often unique state-of-the-art facilities, such as nuclear physics accelerators, reactors and high-energy physics machines.

3. A significant fraction of the facilities have been committed to serve the needs of identified users.

4. The number and variety of ways in which the laboratories can facilitate user arrangements and interactions, have increased for both the large and small sized enterprises.

5. **Achievements/Benefits**

   (1) US industry has been turning with increasing frequency to the use of these large, complex, sophisticated facilities, equipment, software, and collection of expertise. The users, hosts, and funding agencies all benefit substantially, as does the nation, from more efficient and productive use of limited resources for scientific and technological research.

   (2) Users gain the opportunity to work at the frontiers of knowledge with state-of-art equipment that would be difficult or impossible to duplicate at their home institutions.

   (3) Users also acquire a new understanding of the technological developments taking place at the host

institutions. They are thus able to interact with other users from a variety of institutions.

(4) Host institutions gain new insights and perspectives that come from working-level interactions with a broad segment of the technical community, and can therefore direct in-house research into the most productive and meaningful areas.

(5) Sponsors benefit from full utilization of the research capabilities in which they have invested, with the satisfaction that the national laboratories are building, operating, managing and maintaining those facilities for the broad national interest.

(6) There is improved integration of the overall scientific and technological enterprises of the country; resulting in the creation of user facilities where the best talents from the academic, industrial and government research communities can work and meet cooperatively to discover, innovate, and solve problems in areas vital to the nation and its economy.

A13: FINEP, BRAZIL

FINEP, studies and projects financing agency, is a government enterprise linked to the Ministry of Science and Technology.

It was created by Decree No. 61.056, of July 24, 1967, with the objective of stimulating studies and researches capable of enhancing science and technology in Brazil.

FINEP acts in the financing of all phases of the creation process and knowledge absorption: from basic research at academic institutions to the development and use of new technologies at corporations. (Butler, R.G.J., 1989; AAU,1989b).

The activities of FINEP may be classified into four functions:

(a) as a government enterprise, it supports the execution of studies and projects, the technical and financial capacity

of Brazilian consulting firms and the technological development of national corporations;

(b) as the Executive Secretariat of the National S & T Development Fund, it regulates the utilization of its resources in priority programs and project programs and projects according to the criteria established by the Basic Scientific and Technological Development Plan.

(c) as the Executive Secretariat of Coordinating Commission of the Articulation Nuclei with the Industry (SE-CCNAI) it is responsible for promoting the substitution of imports of capital goods and engineering services by public corporations;

(d) as responsible for managing the funds of the Program of Energy Mobilization (PME), created with the objective of promoting energy conservation in general and the substitution of the oil products through the utilization of alternative sources.

CREDIT LINES

Finep has established several credit lines to ensure the effectiveness of its programs. Among these credit lines are:

(a) **ADTEN - Technological Advancement**

The Program of Support to the Technological Development of National Corporations - ADTEN is one of the most important instruments FINEP uses to finance corporations with majority of Brazilian capital and interested in the development of improvement of technology and production processes.

Such projects are performed under the responsibility of these corporations or of consulting firms, or yet within the context of universities and research centres.

The activities supported by this program are:

- national civil engineering concerning technological advancement;

- the establishment of research and development centres;

- the creation of products and processes;

- market tests;

- purchase and absorption of national technology;

- quality control.

(b) **AUSC- Preparation of Studies and Projects**

The AUSC program - Support to users of Consulting Service Corporations - finances the contracting of Consulting services of Brazilian firms for the development of studies and projects of social or economic interest to public or private entities.

This program includes:

- feasibility studies;

- basic projects (in Brazil);

- resulting projects;

- studies and projects aiming at the development of the operational or productive capacity in the technical and administration area.

(c) **ACN - Brazilian Consulting Corporations**

The support to consulting corporations is given under a special financing program, the Program of Support to National Consulting Corporations - ACN. This program was devised to meet the needs of consulting firms in matters related to personnel and equipment technology. These firms must be registered by FINEP before they apply for financing. At the other end, firms interested in the services offered must have a permanent group of personnel specialized in this area.

The ACN program includes:

- internal investments destined to improve the technical level of consulting firms, their efficiency and activities (for example, the establishment of technical files and information centres) as well as the development of computer and management control systems;

- preparation of technical or administrative material, evaluation, design or reproduction, and training of personnel;

- financial support for the execution of services which require funds larger than those normally granted;

- the exportation of consulting and technological services since this can facilitate the access of Brazilian corporations to the international market (new markets, promotion activities and projects preparation).

(d) **FNDCT**

FNDCT represents the main instrument of financial support to scientific and technological research in the country, responsible for the development of projects in the most different areas of knowledge performed by Universities, national research centres and institutes.

(e) **Types of Operations**

Besides FNDCT financing, which is granted to Universities and Institutes of scientific research for their projects. FINEP offers to corporations the following types of operation:

- financing convertible into share participation;

- share participation;

- share participation in the results of the project;
- participation in the profits of the corporation;

- credit lines;

- R & D contracts on FINEP's initiative;

- reimbursable financing.

3. ASIA:

A14: CHULA UNISEARCH - CHULALONGKORN UNIVERSITY

In March 1986, the Chulalongkorn University, Thailand, established the Chula Unisearch as an autonomous university-based organisation with these aims (1) to forge closer linkages with industry and (2) to promote the utilization of university generated knowledge and technology for the solution of problems in commerce an industry in Thailand. (Sripaipan, C., 1988).

Its principal functions are two-fold namely: (i) to develop, promote and facilitate contacts with industry, government agencies and the community at large in areas of mutual interest and (ii) to coordinate, execute and implement projects to ensure high quality and timely delivery of outputs.

Its objectives are: (1) to utilize knowledge within the University for the maximum benefit and betterment of society (2) to broaden the experience of university staff in the application and development of technologies appropriate to Thailand and (3) to represent the University in legal negotiations on contracts under Chula Unisearch control.

Chula Unisearch uses the university academic staff to research and advise on projects. The university resources are mobilised and used for a very wide scope of programme activities in science and technology science, and the humanities.

It is a well-structured organisation. Its Director and Deputy Director are full-time university paid staff. The Office Manager, two Project Coordinators, three office support staff and one janitor are full-time paid staff of Chula Unisearch. It is governed through two Boards, namely the Board of Directors and the Executive Board. Its clients are primarily from different sized private industries as well as government and state enterprises.

According to the commercialization policy of Chula Unisearch the researchers sell the technology they have developed at the end of the applied research phase, then handover the prototype plus some instructions to the manufacturers who must be technically competent, and able to absorb the technology to solve problems in production and in production operation. The researchers are also expected to maintain continuing interest beyond the initial production necessary to continuously upgrade the product. Commercialization is thus a very important source of income generation.

Chula Unisearch is a very effective university productive sector linkage offering services in technology transfer; management and financial advice to private firms; quality control to improve productivity etc; and translation service involving the translation of technical training manuals from English to Thai and vice-versa, on request.

A15: SINGAPORE SCIENCE PARK

Singapore is a city state with a population of 2.6 million people. It has two universities and several Centres of Excellence and Research. The main objectives of Singapore's R & D policy are to:

(i) improve the design and development capability in established industries, and

(ii) develop competence in the new technologies which are expected to contribute to economic growth.

The establishment of centres of Excellence in both universities and the development of Singapore Science Park are integral parts of R&D infrastructure. In addition, there are fiscal incentives and cash grants for the promotion of industrial R&D.

Singapore's R&D expenditure doubled within the five-year period, 1987/88. It is now about 1% of the country's GNP.

The Science Council of Singapore (SCS)

The SCS was established in 1967 to advise the government on all S&T matters, recommend effective training and utilization of S&T manpower and establish relations in S&T matters with other countries.

The members of the Council are drawn from academia, government and industry.

The Council's mission since 1986, is to promote the growth of the technology-based innovation process in Singapore.

Two of the Council's major activities are the administration of a special grant scheme for R&D and the Singapore Science Park.

The Science Park

The Park has, over the past five years gradually developed into a centre of industrial R&D and high technology in Singapore. The objective of the Park is to accommodate wholly R&D-oriented organisations and operations whose activities or manufacture of technology-based products include a substantial amount of R&D.

The 115 hectare park is located next to the National University of Singapore - including the Institute of Systems Science and the Institute of Molecular and Cell Biology - and the National University Hospital. This location fosters close human interaction and pooling of talent between industrial researchers and the university staff.

The SCS actively encouraged interaction among the researchers and more importantly between them and the staff of the nearby tertiary institutions. The total number of R&D firms in the Park is now over 40.

The Science Park Admissions Committee set up approve applications for admissions into the Park and established the following criteria for screening applications.

- R&D Content (substantial R&D budget in relation to total operating budget)

- Technology Content (high-tech and high value added per worker)

- Manpower Profile (high percentage of personnel in technical R&D work)

- Strategic Value (operations with catalytic effect on growth of the Park)

- Non-Pollutive or Land Intensive.

The Science Council also plays an important role in promoting S&T by generating increased awareness of R&D activities in Singapore through conferences, seminars, fora and publications. (SCS, 1988).

A16: UNISERV CHIANGMAI UNIVERSITY OF THAILAND

The Chiangmai University established the UNISERV in 1987 as an independent, non-profit, university-based, affiliated Institute as its UPS Linkage through which it channels its contribution to society by (1) enhancing private entrepreneurial role in Thailand's northern regional economic development process (2) promoting sustainable industry - University cooperation for organised R&D activities suited to private SMI sector needs (3) mobilizing its academic staff to provide improved technologies to the SMIs. (Chulasai, C., 1988).

Uniserv is headed by a full-time Director assisted by four full-time administrative personnel. It is governed and administered through an Executive Board comprising five university representatives and five other representatives from the private sector.

Its objectives are three-fold :

(i) to provide academic consulting services and training to private and public organisations and groups in the Northern Region of Thailand.

(ii) to mobilize existing human and physical resources to serve the public need in the north.

(iii) to provide service to the community by enlarging the knowledge and experience available in the university:

Its functions are to mobilize and utilize academic resources to: (a) undertake background and related applied research assignments on behalf of various government organisations, ministries and state-owned enterprises; (b) provide on-the-job and research training to graduate students in techniques of data collection, conduct of surveys and other related applied research work through assignments commissioned to Uniserv.

The scope of Uniserv activities embraces (a) Extension Services (b) Consulting Services (c) Technology Transfer Mechanisms/Services and (d) Project Advisory Services. Its programme activities, though non-profit making, are self-supporting, as most activities are fee-based. Uniserv is making a remarkable progress as an effective university productive sector linkage and the Chiangmai University has decided to provide it with annual subvention to enable it operate with much flexibility.

A17: THE UNIVERSITY OF PHILIPPINES LOS BANOS FOUNDATION, INC. (UPLBFI)

Responsive to clients' needs, the University promoted the utilization of university - generated technologies capable of mass-production by pooling its expertise into a single institutionalised body, the UPLBFI in 1977.

UPLBFI is a non-university-based corporate organization. Its objectives are to: (i) make the institutionalized service of university experts and their generated technologies available and accessible and (ii) serve as an alternative financial generator by undertaking projects-implementation with much flexibility.

Its functions are: (1) to initiate, conduct and manage R&D projects (2) to design, develop, improve and adopt strategies and systems for developing agriculture etc. (3) to maintain and develop manpower capabilities through training and formal education; (4) to encourage, underwrite, and trade in patents, technology etc. (5) to enter into contract with, execute with any person, organisation or

association, public or private, any lawful agreement for the study and management of rural development, and related enterprises and projects.

UPLBFI experts specialise in a wide scope of programme activities: eg.they conduct action projects and R&D in various fields including, biotechnology, irrigation and water management etc. UPLBFI solicits and explores projects, particularly consultancies for prosecution by its experts, and private external Agencies.

UPLBFI is governed by a Board of Trustees comprising the UPLB Chancellor (as Chairman), three (3) Vice Chancellors, and Deans of Colleges. An Executive Director manages the UPLBFI. UPLBFI has policy guidelines for managing and implementing projects, which are (1) discipline specific or interdisciplinary, or (2) as joint collaborative ventures with the client or funding agency. The projects have to be cleared by the Office of Director of Research or Office of the Director of Extension in the University.

The two main project funding sources are government and private agencies (clients).

Each project is managed by a project manager/leader/ coordinator, with responsibility for the project's performance and outputs generation.

UPLBFI exercises financial control over the project funds and transmits technical reports on activities and accomplishments to the client/funding agencies.

All the fruits of research and other benefits accrue to the unit administering the project while the interests (income) earned from projects funds, go into UPLBFI chest.

From the proceeds accruing to it from operating income generating projects, the UPLBFI supports the University in several ways:

(1) provides professorial chairs and other incentives to outstanding university staff members

(2) offers scholarships for deserving students

(3) finances community development projects.

(4) provides financial assistance to R&D efforts of graduate students and junior faculty members

(5) provides financial assistance to outstanding faculty members for book writing etc.

(6) provides soft loans to market vendors etc. in the community.

Through the UPLBFI the university-productive sector linkages effectively relate University functions to the community needs and aspirations. (Custodio, H.C. and E.D.Bello., 1988).

A18: THE CHINESE ACADEMY OF SCIENCES: SPIN-OFF COMPANIES

The Chinese Academy of Sciences is the highest academic body in China. Its members are actively engaged in teaching and research in tertiary institutions and industry. Two spin-off companies established by a group of scientists of the Academy and the Academy itself are the Stone Corporation and the KeHai High-Technology Group respectively. (PRODEC, 1988).

The STONE CORPORATION was established by several scientists of the Chinese Academy of Sciences in 1984 with a loan from the Evergreen township of Haidian, Beijin. STONE is a self-financing, independently-managed, non-governmental enterprise. It is in the micro-electronics and information processing business.

The KeHAI GROUP is a joint venture of the Chinese Academy of Sciences and the People's government of the Haidaian District of Beijin Municipality. The group owns ventures oriented to the development and manufacturing of computer systems, electronic products, communications systems, biological products, new materials and agro products. The Chinese Academy is the Group's technical back up.

4. EUROPE:

A19: HELSINKI UNIVERSITY OF TECHNOLOGY, FINLAND

The Centre for Continuing Education (CCE) is a university-based independent institution established in 1989. It operates under the University Council, and is managed by a Board chaired by the University Vice-Rector and has a full time Director and supporting staff. The Centre provides continuing education in engineering to graduate engineers within the various fields of specialisation available at, or connected with the Helsinki University of Technology. Its educational programme combines scientific knowledge and the latest technological developments of the University with the expertise of the Finnish economy and the public sector. The objective of this programme is to organise a firm support for the professional development of the key personnel in enterprises. The course activities are concentrated on international business, general management and information technology. A typical course covers 406 weeks and is divided into several modules.

An advisory committee, made up of 4 experts, is responsible for the planning and development of all courses. Detailed planning is done by the course directors and teachers drawn from the University.

The Centre for Continuing Education provides services for examining professional skills necessary for different tasks within technology and engineering, by means of surveys and diverse contacts with enterprises, especially those involved in high technology R&D programme activities.

In recent years the Centre has built up facilities for the provision of services at the international level.

A three-year Managing Technological Change project, which was begun by the Centre in 1989, invites top foreign experts to Finland to consult with firms and teachers at universities. The objective of the project is to create lasting international exchange and permanent technological cooperation. The project is guided by an advisory board appointed by the Ministry of Trade and Industry.

The Centre plays an advisory role through its nation-wide cooperation arrangement with the National Board of Vocational Education whereby it helps the technical colleges to review regularly their teaching materials in the new and rapidly developing areas of technology.

The headquarters of the International Association for Continuing Education in Engineering (IACEE), founded in 1989, is located at the Centre. The IACEE offers many opportunities to Finnish universities and companies to play an active role in the international research and development projects dealing with continuing engineering education. The Centre develops methods of technology transfer, provides education, training and consultancy services and acts as an intermediary channel for providing other university services. (Markkula, M., 1988).

A20: THE INDUSTRIAL RESEARCHER EDUCATION AND THE TRANSFER POINTS

I. IN FINLAND

Industrial organisations receive young researchers who want to obtain their PHD or similar qualifications through studying and working in an industrial rather than in an academic environment. The thesis project work was mostly to be closely related to practical problems e.g the development of a new product. A programme of this nature has been running in Finland. The young graduate engineers continue their studies in an industry and the university pays most of the student's salary. The contents of the work must be accepted and guided by a supervising group set up by the University.

IN DENMARK

A similar programme, though differently organised, has been in operation in Denmark since 1970. The course work and the thesis work together last 2-3 years and lead to a degree called "Industrial Researcher". The programme is governed by a committee consisting of industrial and academic personnel. For each project a steering committee is established. Its members come from the Company and from the university department that will offer the degree. The student is formally employed by the company. Much of the research

work is done in the Company's Laboratory. The university takes care of the course work component.

II. "TRANSFER POINTS" - NETHERLANDS & TECHNOLOGY TRANSFER

In 1980 the Dutch Universities started to strengthen and systematize the already existing contacts between engineering faculties and industry, particularly in the areas of technology and knowledge transfer.

They established a number of what is called Transfer Points at the Universities. In principle a Transfer Point is an Office where industrialists come to make enquiries for help to solve their technical problems, or for developing ideas into mature products. The Transfer Point is a small unit manned by few, (e.g. 2), full time staff members and a clerical assistant. The job of the "Point" is to find the right department where a given enquiry should be sent.

Most of the enquiries come from small and medium-sized firms. In many cases an enquiry leads to a collaborative project between the Company and the university research worker.

The "Points" are initially funded by the government. But this source of funding diminishes as the work of the "Point" flourishes until it becomes self-supporting. (HUT, 1988; Hansen, L.A., 1988).

A21: THE LAHTI CENTRE, FINLAND

Helsinki University of Technology (HUT) is one of the three universities in Finland. The University is responsible for offering higher education in technology and for promoting research activities, and it awards degrees in engineering and architecture. The first degree corresponds to the masters degree in Engineering or in Architecture. The University is a state institution of higher education under the Ministry of Education and has six (6) faculties. The university's institutions which are independent of the faculties include the Lahti Centre, established by the City of Lahti with the cooperation and assistance of HUT.

The operations of the University are funded primarily by state budget appropriations for universities. Income from commissioned research and from other services for which the clients are charged is another important source of outside funding.

The business plan (objective) of the LAHTI CENTRE, located in the City of Lahti, Finland, is to effect the transfer of technology from the Helsinki University of Technology to enterprises in Lahti. The Lahti Centre has its own head and its own Board of Directors who are appointed by the University Council. The head runs the Institution, with the assistance of the Board of Directors, the members of which are selected from several branches of technology (e.g. industrial economics, manufacturing technology, computer science, mechanical wood processing, and technical physical). In addition, the staff of the Centre combines knowledge and experience from a wide range of technological branches of the University of Technology as well as of industry in Lahti.

External courses for engineers without university qualifications were started at the Centre in 1988. The programme activity is gradually being expanded to provide, eventually, postgraduate education and research in technology. The Centre's policy is to encourage most workers who work in industry in Lahti to take advantage of the Centre's scheme which offers study guidance and opportunities for taking courses for university degrees.

Continuing Education at the Lahti Centre focuses on demonstrating the results of the research prosecuted by the laboratories of the university - with the primary aim of making enterprises aware of the progress and achievements of the new technologies immediately beneficial to the participants, and consequently available for the development of traditional industry. (HUT, 1988; HUT, 1990).

A22: THE TEACHING COMPANY SCHEME (TC), UNITED KINGDOM

This was established in the UK during the late 1970s jointly by the Science and Engineering Research Council (SERC) and the Department of Trade and Industry (DTI).

Its aim/objective is to create active partnerships between engineering schools (i.e universities and polytechnics) and industry for the following purposes.

(a) to raise industrial performance by the effective use of academic knowledge and capacity

(b) to improve manufacturing and industrial methods by effective implementation of advanced technology

(c) to train able engineering graduates for careers in industry

(d) to develop and re-train existing company and academic staff

(e) to give academic staff a broad and direct association with industry, in order to provide them with background for research and teaching.

The Teaching Company scheme (TC scheme) is controlled on a national level by a management committee consisting of equal numbers of senior academics and industrialists. The Committee considers applications for grants. A directorate with a supporting staff is responsible for the day-to-day running of the scheme.

The Scheme is funded partly by SERC and partly DTI. Each programme lasts 2-3 years and is managed by a Local Committee. The Scheme is called "Teaching Company" for several reasons. One of these reasons is that the young associate graduates (under 29 years), who are employed formally on two-year contracts by the participating university to assist industry improve its operations , benefit greatly by improving their own education during the period of their association with the programme. They emerge from the Scheme more experienced in an area of industry where skills are in short supply; they also become more mature in their approach to problems. (Fishwick,W., 1983; Hansen,L.A., 1988).

A23: THE IDEON COMPLEX, SWEDEN

IDEON was created as a result of economic stagnation and recession in the traditional branches of industry in the South Sweden region, the combined state and regional efforts for structural change and renewal in industry and the availability of a large accumulation of knowledge, competence, creativity and scientific and technological and highly-skilled manpower resources at Lund University and the Swedish Agricultural University in the region.

A university professor conceived and launched the idea for an IDEON research park, near the Lund University Institute of Science and Technology, where blocks of buildings with appropriate premises designed purposely for high technology research and development work are located. The Lund University Board and the Sun Foundation (for the promotion of industrial development through scientific research) were approached and they completed the requisite plans and arrangements for the establishment of the nucleus, namely the Research Park, as the first IDEON complex in 1983 with the effective and expeditious administrative support from the Lund County Council. The Government of Sweden encouraged the establishment of the Park by allowing the first company, Ericsson Radio, that moved into the Park to use part of its investment funds to finance its company at the Park. This formed the first financial basis for IDEON.

The broad objective of IDEON is to convert knowledge and research findings into new products and processes which can be utilised in industry and society at large. Thus within the walls of IDEON, theory and practice are mingled in companies that depend on research and development. But the Research Park of IDEON is the place where IDEAS for new products and processes are developed.

There are at present about 100 companies in IDEON Lund Research Park. The IDEON Research Park is governed by a Board with representatives from the Sun Foundation, Lund University and the City of Lund. There is the IDEON CENTRE which is responsible for maintenance, services to companies, marketing and arrangements for visitors and conferences. The special organisation - IDEON Management- offers expert advisory services to newly started companies in the Research Park. There is also the special business

school, called IDEON START, for those who plan to start a company in the Research Park.

Newly started companies are housed together in one location known as the Incubator. All the premises/accommodation and other facilities needed to foster the steady and efficient development and growth of the newly started companies are available in the specially-built buildings (eight in number) belonging to two (2) property-holding companies. The newly started companies thus operate in rented premises.

The IDEON Research Park in Lund, the first complex to come into existence, is now the biggest of the IDEON branches.

The second IDEON complex, known as the IDEON MALMO was established in 1984 in Malmo with strong ties to the research organisation of the neighbouring Malmo General Hospital and Malmo School of Dentistry, and a dynamic pharmaceutical industry. Its primary objective is to specialise in medical technology, pharmaceutics and handicap technology.

IDEON Malmo already has 10 "development" companies at work. Its Board of Governors has representatives from the SUN Foundation, Lund University and the City of Malmo, with a Chairman from the Malmo country commissioner. a special private company known as MEDEON AB is responsible for creating functional Research and Development (R&D) premises (i.e offices and laboratories) at IDEON Malmo, and it involves a huge financial investment by MEDEON AB.

Large pharmaceutical companies have set up R&D divisions, side by side with small spin-off companies, at IDEON Malmo.

The third IDOEN was established about 1984 in Lund as their IDEON complex. This INDUSTRIAL PARK is intended for companies at the prototype stage, or the first stages of serial production. Chemistry, electronics and biotechnology are the principal areas of interest. A company that succeeds in developing ideas for new products and processes in the Research Park enters the next phase of its development in the IDEON Industrial Park.

About a dozen companies are now established in IDEON Industrial Park in Lund. The buildings here contain adequate

premises for companies that require a little more space for activities like prototype development, small scale production, marketing and sales. The maintenance and services to the companies are the responsibility of a special private organisation/company.

The fourth IDEON organisation known as IDEON-Agro, was formed in 1986 on the initiative of the SUN FOUNDATION. Its primary objective is to promote increased cooperation between research and industry and to function as a powerful facilitator/centre for applied research in agricultural production and the food industry, and horticulture. Its scope of activities fall into three (3) broad areas, namely:

(i) projects intended to create new business concepts/ideas for industries;

(ii) conferences and advanced training programmes and

(iii) information and services.

In the area of increased cooperation between research and industry - IDEON Agro engages in the development of new qualities in traditional crops and the finding of new markets for agricultural products to counteract the adverse effects of constant fluctuations in the markets for agricultural products. In the areas of over production of food products, IDEON Agro engages in work intended to ensure improvements in the processing of food products. IDEON Agro is closely linked to research at the Swedish Agricultural University and Lund University and its Institute of Science and Technology. Unlike the other (3) IDEON branches, IDEON Agro often carries out preliminary cooperative studies and analyses directly with companies that commissioned the project up to the penultimate stage. Then the last steps towards the realisation of the business concept/idea, are taken by each company on its own.

However all activities at IDEON Agro are undertaken on the basis of prior recommendations of an Industrial council of representatives of leading food producers in South Sweden.

When IDEON was created in 1983 a repressed entrepreneurial spirit readily found an outlet and many (35) companies, effectively and efficiently operational were established within two (2) years.

They included R&D divisions of large industrial enterprises (e.g. Ericsson, Asea & Perstorp) as well as one-man spin -off companies from the University in Lund /Malmo.

Most IDEON companies work in fields where Lund University is also particularly strong (eg. chemistry, biotechnology, computer technology, medical technology, electronics, transport technology, environmental technology, transport technology). The Lund University has also benefitted a great deal from these companies e.g by getting access to equipment owned by the companies and having new professorships financed by industry. New job opportunities have been created through IDEON chain reaction by which one advanced scientific and technological activity attracts another, which also attracts another. Thus the region has benefitted from new jobs created within IDEON, as well as in companies that provide IDEON with services eg. construction & transport companies, hotels etc. Regional infrastructure is being strengthened as a result of increased demand for professional services eg. improved communications, particularly international air traffic. The University at Lund/Malmo continues to make more efficient use of its teaching staff. Industrial experience and practical know-how are brought to the University by its staff working in IDEON.

"Technology of today" i.e applied research and industrial development is largely financed by the industrial enterprises themselves. The "Technology of tomorrow" i.e a mixture of basic and applied research is more dependent on public funds (state-financed). The "Technology of the day after tomorrow" i.e very long term open-ended basic and applied research - is primarily a government financial responsibility. However industry makes contributions towards the purchase of equipment and funding of research services as a welcome addition to government grants.

Activities at IDEON range from the technology of today to that of tomorrow generally. But in certain fields eg. computer technology and biotechnology, there is no sharp distinction between basic research and certain application within a few months.

"IDEON" may be regarded as a classic example of University productive sector linkages- mechanism/instrument with beneficial relationships involving virtually all sectors in the economy of south Sweden (vis-a-vis research/university, private enterprise,

communities and the government agencies). Indeed the University and IDEON, with their network of contacts, have built a bridge to Europe and to the other continents, particularly through cooperation between Sweden and Denmark and through Danish membership of the Common Market of EEC. (Ayiku, M.N.B., 1988).

5. INTERNATIONAL

A24: "COMETT" COMMUNITY ACTION PROGRAMME FOR EDUCATION AND TRAINING FOR TECHNOLOGY OF THE EUROPEAN COMMUNITY

The COMETT Programme was established in 1986 by the European Community. It provides financial support on a cost-sharing basis for the organisation of five (5) so-called strands or components of action. (Prosser, E., 1988).

The Programme is closely coordinated with other European Community's R&D programmes. Its objective is to provide vital training dimension necessary to its programmes and to ensure scientific and commercial success. Its functions are:

1. To give a European dimension to university-enterprise cooperation in the field of new technologies

2. To foster the joint development of training programmes, the exchange of experience, and the joint use of training resources at the Community level

3. To improve the supply of training at local, regional and national level with the assistance of the authority concerned, and contribute to the balanced economic development of the Community

4. To develop the level of training in response to technological and social changes by identifying the resulting priorities in existing training arrangements which call for supplementary action both within Member States and at community level, and by promoting equal opportunities for men and women.

The (5) five strands/components of action of COMETT are:

Strand A: "UETPs" are Consortia of Universities and firms joined together "for better" prospects in training partnership. They are cooperative initiatives at the local, regional or national level bringing universities and enterprises together on a structured and coordinated basis to meet the need for highly qualified manpower. They arrange for student placements, exchanges of personnel, continuing education programmes, and media-based actions. They can be geographically or sectorialy based.

COMETT creates a network of these Consortia throughout the Community as a backbone for training, collaboration and exchanges.

Strand B - provides funding to assist in moving people simultaneously between universities and enterprises and across national frontiers.

Strand C -supports 2 types of initiatives.

1. Development and testing through transnational joint efforts of training materials and packages for use in firms. Such materials are directed at personnel seeking new or additional advanced level skills and knowledge. The materials should be capable of wide dissemination and utilisation.

2. Organising short high level and quality intensive courses for the rapid dissemination of the latest R&D results within universities and enterprises.

Strand D - utilizes the potential of the new technologies themselves as tools for improving teaching capacity, addressing the potential of media-based instruction and computed-assisted learning, and supporting initiatives designed to provide and improve structures through which media-based learning can be provided.

Strand E - provides the supporting information and evaluation actions for the Programme (in the field of monitoring of skills and manpower requirements).

A25: THE "ERASMUS PROGRAMME - (EEC)

On 15th June 1987 the Education Ministers of the European Community adopted the European Community Action Scheme for Mobility of University Students ("ERASMUS") - Programme. (Haug, G., 1988).

The main objective of the Programme is to help boost student mobility between the 12 member states of EEC well above its present level, by providing opportunities for more students than hitherto possible to spend recognised periods of study in another Community country.

Action 1 - European University network. The programme awards -

a. Grants to higher education institutions to facilitate the planning, development, operation, maintenance, monitoring and evaluation of inter-university projects for exchange of students and teaching staff.

b. Grants to help cover the travel and subsistence expenses of teaching staff carrying out teaching assignments in another Member State.

c. Grants made to facilitate visits to other Member States by members of teaching and administrative staff of higher educational institutions with a view to establishing contacts for future cooperative programmes and/or for the purpose of acquainting themselves more thoroughly with aspects of the higher education system in the countries visited.

Action 2 - Grants are awarded to students -

The grants cover:

a. "mobility costs" in another Community country.

b. free tuition for grant holders at their host university.

c. During the period of study in another member state of the Community, the grantees continue to enjoy any home country grant or loan from government or government-funded sources for the purpose of study in their own country.

Action 3 - Academic Recognition of degrees and course units

a. Grants will be given for the development of common curricula between higher educational institutions in different Member States.

b. The scheme known as the European Community Course Credit Transfer System has been established for academic recognition of degrees.

Action 4 - Additional Measures

a. Grants are given to facilitate the organization of "Intensive Teaching Programmes of short duration involving students from several Member States.

b. Grants are made to University associations and consortia operating on a European basis with a view to making innovations in particular areas more widely known throughout the Community.

c. Support is given to enable top-level experts to give a series of lectures in other Member States.

d. Publications and other information measures designed to raise awareness of opportunities for study and teaching in other Community countries and to disseminate information on innovation models for inter-university cooperation are encouraged.

e. Prizes are awarded to students and higher education staff members who make particularly outstanding contributions to furthering inter-university cooperation in the community.

A26: IACEE; THE INTERNATIONAL ASSOCIATION FOR CONTINUING ENGINEERING EDUCATION

The IACEE was formed in May 1989 in Beijin (China) as an independent and non-profit making organization. It was the culmination of a clear and growing international consciousness of the high importance of CAREER DEVELOPMENT and CONTINUING EDUCATION

by various national, regional and international organizations engaged in continuing engineering education.

Its objectives are to:

(a) provide an efficient channel for concerted efforts to develop models and systems for continuing education which can be used in different environments by professional engineers.

(b) support and enhance lifelong technical education and training, and advanced engineering education world-wide, including the special needs of developing countries.

Its functions are to:

(a) promote technology transfer through a better understanding of the continuing education process

(b) improve the quality of education and training of engineers and technicians, and of technical information scientists through international corporation

(c) develop and strengthen cooperation between education and industry

(d) support the equality of women in engineering through continuing education

(e) initiate international and regional meetings and conferences on continuing education and provide technical assistance in conducting them

(f) promote R&D in the field of continuing engineering education carried out in close cooperation with the members of the Association.

(g) develop:

(i) Models for organising successful continuing engineering education and comparative studies on CEE world-wide, on the short-medium term

(ii) capabilities for tackling major projects such as: distance education through intercontinental satellite communication; regular centres for continuing education; and support methods in distance education where feasible on the long-term.

The IACEE forms an excellent forum where participants learn from each other's experience. (UNESCO, 1988a; IACEE, 1989).

A27: COOPERATION BETWEEN ENGINEERING COLLEGES AND INDUSTRY IN SOUTH EAST ASIA

I. The Association for Engineering Education in South East Asia (AEESEA)

The Association was established in 1973 with the assistance of UNESCO.

The Association operates on a rotational basis, where a country voting-member takes turn to host the Secretariat of the Association for 3 years.

The Association fosters cooperation among engineering colleges and professional engineering institutions in South-east Asia. Membership of the Association includes the Philippines, Korea, Australia, Thailand, Japan, Malaysia, and Singapore.

The regular exchanges of information and experience among members have been by communications through the Journal of Engineering Education in Southeast Asia (JEESEA), and the Newsletters.

The Association organises a conference every 3 years, traditionally in the country where the secretariat is to be transferred.

One of the objectives of the Association is to promote engineering industry cooperation.

Conference reports have revealed that:

(a) cooperation between engineering education and industry in most developing countries was weak as at 1983

(b) in the industrialised countries such as Singapore, Korea, Australia and Japan cooperation between engineering education and industry was much better. It was reported that in 1984 Korea developed a mutual cooperation arrangement between University and Industry in postgraduate research activities - the Engineering College of Seoul National University received massive research funds from industry.

II. Consultancy Services in Southeast Asia

The Institute of Consultancy at the University of Pertanian in Malaysia has been established to promote and coordinate consultancy activities at the university. The Institute acts as an industrial liaison with industry for consultancy and research services.

In Australia University consulting services have been widely accepted as one way of strengthening cooperation between engineering colleges and industry. Most universities have set up a consulting service unit as an autonomous and independent body operating in a business manner, such as ANUTECH of Australian National University, INSEARCH of New South Wales Institute of Technology and UNIQUEST of University of Queensland.

These bodies have been established as a means of creating an industrial liaison with industry. The scope of cooperation through the Consultancy Service Units includes consulting, testing, designing, research and development of new products and processes.

The Australian model is followed by several institutions in Southeast Asia. (Boonyubol, C., 1988).

APPENDIX B: REFERENCES

1. AAU, Proceedings of the Workshop on University Resources and Financial Management, AAU, Lome, Togo, 1987.

2. AAU, Regional Cooperation in Commercialisation of Results of University Research in Africa, paper presented at Conference on Commercialisation of R & D Results, Lagos, 23-27 April, ARCT, 1989a.

3. AAU, Study Tour of Brazil Report; AAU. 1989b.

4. Adjebeng-Asem, S., Social Factors influencing the Translation of Innovation into Entrepreneurship, IDRC, Ottawa, May 1988.

5. Aju A., Strategy for Promotion of Technological Innovation through Adoption and Diffusion of Indigenous R & D. Paper presented at ARCT workshop on Commercialisation of R & D Results, Lagos, Nigeria, April 23-28 1989.

6. Akinyemi Sawyerr, J., Financing Technological Innovation Including R & D on a Commercial Basis by the Private and Public Sectors, paper presented at International Workshop on Commercialisation and Evaluation of R & D Results", Lagos, Nigeria, 23-27 April, 1989.

7. Aminu, J., Partnership in Science and Technology Development. National Conference on Universities, Research Institutes: Partnerships and Technological Development, Port Harcourt, April 1-3, 1987.

8. Asian Productivity Organisation (APO), Industry - Academic - Government Collaboration for Technology Development, APO, Tokyo, 20-23rd Feb. 1989.

9. Awokoya, S.O., A Synthesis of the Issues, Problems and Strategies for the Human Resource Development Programme in the Lagos Plan of Action, in ECA, The Role of African Institutions of Higher Learning in the Implementation of the Lagos Plan of Action, ECA, Addis Ababa, 1982.

10. Ayiku, M.N.B., Study Tour of Europe. Technology Transfer Centre, Accra, 1988.

11. Ayiku, M.N.B., Ripples in the Intellectual Property System: A Challenge to South-South Cooperation, Development and South-South Cooperation, Vol. V. No.8, CICD, Ljubljana, Yugoslavia, 1989.

12. Azucena, C.F. (ed), Universities and Application of Research, Proceeding of a workshop, Singapore, 19-20 Sept. 1988, IDRC 1988.

13. Badawy, M.K., Key Issues in Building Linkages between Industry, Academia and Government in Technology Development in the USA in APO, Industry - Academic - Government Collaboration for Technology Development, APO, Tokyo, 20-23rd Feb. 1989.

14. Boonyuboi, C., Recent Experiences and Activities in Engineering Education/Industry Cooperation in Southeast Asia, in UNESCO, 1st Joint Meeting of the International Working Groups on Engineering Education/Industry Cooperation (EEIC) and on Continuing Education, 16-20 Oct.1988, Paris, HUT, Finland, 1988a.

15. BSMBD, Financing Programmes for Cottage, Small and Medium Industries, BSMBD, Department of Trade and Industry, Manilla, Philippines, 1989.

16. Butler, R.G.J., Study Tour of Brazil, Washington, DC and London, Technology Transfer Centre, Accra, 1989.

17. Cendros, J. and L. Ricon., An Experience in University-Industry Links, in Ohio State University(OSU), Proceedings of the Symposium for Engineering Deans and Industry Leaders, Ohio State Univ., Ohio, USA, July 17 1989.

18. Chaparro F., Increasing the Utilisation of Research Results: A Framework for Centre Action in the LARO REGION. IDRC/LARO, Bogota, 1988.

19. Chulasai, L., The UNISERV Chiangmai University in Azucena, C.F. (ed), Universities and Application of Research, Proceedings of a workshop, Singapore, 19-20 Sept. 1988, IDRC 1988.

20. Cookey, S.J.S, Emerging Links between Universities and Industry: An Overview. National Conference on Universities, Research Institutes: Partnerships and Technological Development, Port Harcourt, mimeo. 1987.

21. Custodio, H.C. and E.D.Bello., Universities and the Promotion and Utilization of Research Results: Case Experiences of the University of Philippines, Los Banos in Azucena, C.F. (ed), Universities and Application of Research, Proceeding of a workshop, Singapore, 19-20 Sept. 1988, IDRC 1988.

22. ECA, The Role of African Institutions of Higher Learning in the Implementation of the Lagos Plan of Action, ECA, Addis Ababa, 1982.

23. ECA, Africa Alternative Framework to Structural Adjustment Programmes for Socio-Economic Recovery and Transformation, ECA, Addis Ababa. Doc. No. E/ECA/CM.15/6/Rev 3, 1989a.

24. ECA, Application of Research Findings in the Development of Pharmaceutical Industries on the basis of Indigenous Raw Materials. Doc. ECA/IND/CHN/003/89, Addis Ababa, ECA, 1989b

25. ECA, Economic Report on Africa, 1989. ECA, Addis Ababa, 1989c

26. ECA, Handbook for Manpower Planners in Africa. Doc. ECA/PHSD/89/26/6.1 (iii)(a), ECA, Addis Ababa. 1989d

27. ECA, Review of Laws which Govern Patents in Africa, doc. No. S&T/IGESTD/1.3(c), Addis Ababa, Nov. 1989e

28. ECA, Roundtable Discussion on Invention Licensing and Commercialisation Options for Research Institute in Africa, Nairobi, Kenya. 1 - 3 Feb. 1989. ECA Doc. No. ECA/NRD/TC/ ST5/3/89/1.1(b), 9th Feb 1989f

29. ECA, Development of Entrepreneurs Capability for Small Scale industries in Africa. 1989g

30. ECA, Directory of Project Profiles, 2nd Ed. Doc. No. ECA/JID/85/57. 1989h

31. ECA & UNIDO; Report on the Independent Mid-Term Evaluation of the IDDA and the Proclamation of the Second IDDA. UNIDO, 12th April 1989.

32. ESEE,HUT & ESF, Effective Engineering Education, ESEE,HUT & ESF, 1988.

33. Fishwick W., Strengthening Cooperation between Engineering Schools and Industry. UNESCO, Paris, Studies in Engineering Education, No.8, 1983.

34. Fubara, B.A., University and Industry Research: A Strategy for Maximising National Resource, National Conference on Universities, Research Institutes, Industries: Partnerships and Technological Development, Port Harcourt,April 1-3, 1987.

35. Ghana Institution of Engineers (GIE), Regulations for Practical Training for Engineering Graduates, Accra, 1978.

36. Hansen, L.A., Recent Developments in the Co-operation between Engineering Education and Industry in Western Europe, in UNESCO, 1st Joint Meeting of the International Working Groups on Engineering Education/Industry Cooperation (EEIC) and on Continuing Education for Engineers and Technicians, 16-20 Oct.1988, Paris, HUT, Finland, 1988.

37. Harper, M and Soon, T.T., Small Enterprises in Developing Countries: Case Studies and Conclusions, Intermediate Technology Group, London, UK, 1986. London.

38. Haug, G., The ERASMUS Programme, in ESEE,HUT & ESF, Effective Engineering Education, ESEE,HUT & ESF, 1988.

39. Hahn,S.J., Contract Research and Consulting, Lecture delivered in Accra on 28th July 1989, TTC, Accra. Ghana., 1989

40. HUT, Collaboration in Continuing Engineering Education, HUT, Finland, 1988.

41. HUT, Helsinki University of Technology, Catalogue, the Finnish Government Printing Centre, Helsinki, Finland, 1990.

42. Ibrahim, Y.A., The Structure of Power and Authority in Universities: The Case of Federal Universities in Nigeria in AAU, Proceedings of the Workshop on University Resources and Financial Management, AAU,Lome, Togo, 1987.

43. IACEE, Newsletter, Number 1, Oct. 1989.

44. IDRC, The Link Between Research and Development: The Problem and Elements of a Strategy, IDRC Conference, Report; Dakar, 5th November 1988.

45. IDRC, Discussion Paper: Strategic Choices for Sub-Saharan Africa, IDRC, Dakar, 1989.

46. ILO, The Role of Universities in Workers Education, ILO, Geneva, 1974.

47. ILO, Facing the Technological Challenge, ILO, Geneva, 1987.

48. Jugessur, un Soodurs, Technology Policy and Mechanism for Accelerated Technological Development, ECA, unpublished manuscript, (undated).

49. Klus, J.P., M. Markkula et al, Effective Technology Transfer Project for Developing Continuing Engineering Education in Finland. Katakaoffset Oy, Helsinki, Finland 1986.

50. Koon, T.E., University Administration and Management Principles and Emerging Structures, in AAU, Proceedings of the Workshop on University Resources and Financial Management, AAU,Lome, Togo, 1987.

51. Landi, J.H. and A. Diallo, Small-scale Industries in Rural Development in Nigeria. in Razvoj Development International, Vol. III, Nos. 1-2, Zagreb, Yugoslavia, Jan-Dec 1988,

51. Lwakabamba, S.B. and A.S.Bhandari, Cooperation between Universities, Industries and the Public Sector: The Case of Tanzania.

52. Markkula, M., The Need for New Activities in CEE in Europe, in UNESCO, 1st Joint Meeting of the International Working Groups on Engineering Education/Industry Cooperation (EEIC) and on Continuing Education for Engineers and Technicians, 16-20 Oct. 1988, Paris, HUT, Finland, 1988.

53. Markkula, M. The Need for New Activities for CEE in Europe, European J. of Engineering Education, Vol.14 No.1, 1989a.

54. Markkula,M. New Activities for Universities in Professional Development of Engineers, in Ohio State University (OSU), Proceedings of the Symposium for Engineering Deans and Industry Leaders, Ohio State Univ., Ohio, USA, July 17 1989b.

55. OECD, Industry and University: New Forms of Cooperation and Communication, OECD, Paris. 1984.

56. Ohio State University (OSU), Proceedings of the Symposium for Engineering Deans and Industry Leaders, Ohio State Univ., Ohio, USA, July 17 1989.

57. Omar, A.R., Generation of Technological Innovation for Commercialisation of Research, paper presented at Commonwealth Science Council Workshop on commercialisation of R & D, 24-28th April 1989, Lagos, Nigeria.

58. Oragwu, F.N.C., A Science and Technology Profile of St. Lucia., Commonwealth Science Council, London, 1990

59. Princewill, G.B., Industry, Academic and Research institutional Cooperation: Strategies for Symbiotic Interaction. National Conference on Universities, Research Institutes: Partnerships and Technological Development, Port Harcourt, 1987.

60. PRODEC, Seminar on Technology Transfer and Development, Beijin, 31 Oct-16 Nov. 1988, PRODEC,Helsinki, 1988.

61. Prosser, E., The COMETT Programme in ESEE,HUT & ESF, Effective Engineering Education, ESSE,HUT & ESF,1988.

62. Randolph, Carlos G., Development of a Structure for Research and Transfer of Technology in the Mining Sector. First Regional Workshop on University's Productive Sector Linkages, IDRC, Argentina, November 12-18, IDRC, 1988.

63. Said, A.M., Industry, Public R & D Institution-University Linkages in Malaysia, in Asian Productivity Organisation (APO), Industry - Academic - Government Collaboration for Technology Development, APO, Tokyo, 20-23rd Feb. 1989.

64. Science Council of Canada(SCC), University-Industry Research Centres: An Interface between University & Industry. Proceedings of a workshop held on 22-23 May 1986, Ottawa.

65. Science Council of Canada(SCC), Winning in a World Economy: University-Industry Interaction and Economic Renewal in Canada, Report No. 39, 1988.

66. Science Council of Singapore(SCS), S&T Organisations in Singapore, SCS, Singapore, 1988.

67. Smillie, Ian., No Condition is Permanent: Priming Ghana's Revolution, Intermediate Technology Publication, London, UK, 1986.

68. Sverrisson, Arni; Entrepreneurship and Industrialisation; A Case Study of Carpenters in Mutare, Zimbabwe. University of Lund, RPI, 1990.

69. Sirkeinen, ULLA, Engineering Education/Industry Cooperation in Finland - General Features and Description of A Recent Major Project (Nokia Corporation), Helsinki University of Technology, Finland, 1988.

70. Sripaipan, C., Application of Research Results: Chula Unisearch Experience in Azucena, C.F. (ed), Universities and Application of Research, Proceeding of a Workshop, Singapore, 19-20 Sept. 1988, IDRC 1988.

71. TTC, Strategies for the Development of the SMI Sector in Ghana, Proceedings of a Workshop, Accra, TTC, June 1990.

72. UNCTAD, Impact of Technology Transfer by Foreign Small-sized Enterprises on Technological Development in Kenya, UN, New York, 1987.

73. UNCTAD, Technology Policies for Development and Selected Issues for Action, Proceedings of a Seminar Organised by the Islamic Bank and UNCTAD., Saudi Arabia, UN, NY, 1988a.

74. UNCTAD, Research Institutes and Technology Innovation in Food Industry in Senegal, UNCTAD, Doc. UNCTAD/TT/93, Geneva, 1988b

75. UNCTAD, The Role of R&D Institutes in Technological Innovation: The Case of Sri Lanka. UNCTAD, Geneva. 1988c.

76. UNDP, Strengthening the National Capacity for the Transfer, Utilization and Development of Technology, UNDP Project Doc. Project GHA/88/008, Accra, Ghana. 1988.

77. UNESCO, Science Policy and Organisation of Research in the Republic of Korea. UNESCO, Paris, Doc.No.56 (1985).

78. UNESCO, CASTAFRICA II: The Role of the Human and Social Sciences in the Application of S & T to Socio-Economic Development in Africa. UNESCO, Paris, Doc. No. Sc-87/ CASTAFRICA II REF.4, 1987.

79. UNESCO, 1st Joint Meeting of the International Working Groups on Engineering Education/Industry Cooperation (EEIC) and on Continuing Education, 16-20 Oct.1988, HUT, Finland, 1988a.

80. UNESCO, Science, Technology and Endogenous Development in Africa - CASTAFRICA II, UNESCO, Paris, Doc.No.69 1988b.

81. UNIDO, University-Industry Linkage: Guide to the Establishment of Industrial Liaison Units in Developing Countries, UNIDO/PC.115, May 1985.

82. World Bank (WB), Agricultural Research and Extension: an Evaluation of the World Bank's Experience, World Bank, Washington, DC, USA. 1985.

APPENDIX C: ITINERARY AND PERSONS MET

A. ECA, ADDIS ABABA, 17-20 April 1990

1. Mr. Rashit, Chief, Human Resources Division
2. Mr. M.D. Sarr, Chief, Industry and Human Settlement
3. Mr. A. Makonnen, Dep. Chief, Industry Division
4. Mr. D. Kamara, Project Officer, Industry Division
5. Mr. Grey Johnson, Human Resources Division
6. Mr. Soodnurs un Jugessur, Chief, S&T Unit
7. Mr. Karumuna, S&T Unit

B. HELSINKI UNIVERSITY OF TECHNOLOGY, 12-13 March 1990

1. Mr. A.Hagstrom, IACEE
2. Prof. Iimari Kurki-Suonio, Faculty of Mechanical Engineering
3. Mr. Markku Markkula, MD, CEE and Secretary-General of IACEE
4. Prof. Antti Saarialho, Vice-Rector,HUT
5. Prof. Tapani Jokinen, Faculty of Elect. Engng, Chairman, Finnish COMETT Programme.
6. Mrs. Katriina Schrey-Niemenmaa, Finnish Engineering Society
7. Ms. Sirkka Poyry, Finnish Engineering Society
8. Mr. Markku Mansner, Conferation of Finnish Industries
9. Prof. Martti Tiuri, Member of Parliament

C. IDRC AND ARCT, DAKAR, SENEGAL, 5-11 February 1990

1. Mr. Pierre Sanne, Executive Director, IDRC
2. Mr. Kane, Ag. Executive Director, ARCT
3. Ms. Christiana Cole, ARCT
4. Mr. Moussa Drane, IDRC

D. ILO, GENEVA, 19-20 March 1990

1. Mr. Elias G. Mabere Office of the Director-General
2. Mrs. Helene Chassaing, Management Development Branch
3. Mr. Givesepp Querenghi, Educational Branch
4. Mr. Ballal, Technology and Employment

E. UNCTAD, GENEVA, 20-21 March 1990

Ms. Gloria Veronica-Koch, Officer-in-Charge, Technology Div.

F. **UNESCO, PARIS, FRANCE, 8-9 March 1990**

1. Chief Ibukun, Director, Science Sector
2. Dr. K.M. Sape, Division of S & T Policies
3. Mr. R. Hsieh, Unit of Science-University-Industry
4. Dr. E.M. Sherif, Division of Development and Coordination of Operational Activities
5. Mr. J. Kingston, Division of Scientific Research and Higher Education
6. Dr. B. Ntim, Division of Technological Research and Higher Education

G. **UNIDO, VIENNA, 15-16 March 1990**

1. Mr. H. Prium, NGOs and Industrial Enterprises
2. Mr. G. Assaf, Regional and Country Studies Branch
3. Mr. C. Antonio, Institutional Infrastructure Unit
4. Mr. M. Kapepula, IDDA Coordinator
5. Mr. Rapheal Kabwa, African Programme
6. Mrs. I. Lorenzo, Industrial Human Resources Development
7. Ms. U. Viola-Stromer, Consultant
8. Ms. Fatima-Zohra Bennani, Area Programmes
9. Ms. Savarain, Basic Technologies

H. **UNIVERSITY OF ADDIS ABABA, ETHIOPIA, 18th April 1990**

Dr. Tilatun Workinhe, Liaison Officer

I. **UNIVERSITY OF NAIROBI,NAIROBI, 21st April 1990**

Dr. El Busaidy, Chairman, Chemistry Dept.,

J. **LAGOS, NIGERIA, 31 October - 2 December 1990**

1. Nigerian Institute for Economic Research (NISER)
   Mr. E.A.Alowah (Librarian)
2. Ministry of Science and Technology, Lagos
   Prof. E.E.Okon (Director General)
3. Nigerian Association of Small-Scale Industrialists
   Ms. Bilikisu Usman (Secretary)
4. National Office of Industrial Property (NOIP)
   Mr. F.Okono (Director)
5. Federal Institute of Industrial Research, Oshodi (FIIRO)
   Dr. A.O.Koleoso (Director)